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WAR DEPARTMENT

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TECHNICAL MANUAL

INSTRUCTION GUIDE

INSTRUMENT REPAIRMAN

May 15, 1942

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INSTRUCTION GUIDE

INSTRUMENT REPAIRMAN

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SECTION I

GENERAL

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1. Purpose.—The purpose of this manual is to serve as a practical handbook to be used by the personnel of the instrument section of an ordnance maintenance unit. It may be used by the section leader as a text in training the section, or it may be used by the individuals to aid them in becoming familiar with the more general phases of their work. It must be kept in mind that no hard and fast rules can be laid down which will suit every condition. The exact procedure to be followed in any particular case will be determined by the specific nature of the work to be done, the facilities which are available, and

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the skill of personnel comprising the section. The decisions of the section leader will be guided by the fact that all of these factors must be taken into consideration at all times. This manual will be found useful as a guide and as a working handbook by both the section leader and the individuals of the section.

2. Scope.—This manual deals with the organization, mission, duties, and equipment of the instrument section and covers the more general phases of maintenance operations of the section so often ignored in the texts treating of a specific instrument. It will be kept in mind that the operations described herein are intended merely as a source of general information, and are not to be construed as hard and fast rules, except certain paragraphs extracted from existing regulations and so designated. There has been included, however, a good deal of information relative to the work of the instrument section which will be found useful in the operation and training of the unit.

SECTION II

INSTRUMENT SECTION IN THE FIELD

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3. Mission.—The instrument section has charge of the maintenance and repair of all fire control matériel, sighting equipment, watches, and tripods. It supplies replacements for unserviceable matériel and repairs or adjusts such items. It may be called upon to inspect equipment in the hands of the using service and to render technical advice to the commanders of such units in regard to preventive maintenance operations, storage, cleaning, and preservation.

4. Organization.—The instrument section, medium maintenance company, consists of 20 enlisted men. A technical sergeant exercises control over the section and acts as section leader.

5. Equipment.—*a.* The instrument section in the field has available an instrument repair truck containing adequate facilities and spare parts for accomplishing those repairs and adjustments considered within the limitations of field maintenance operations. The instrument repair truck is the field shop. It is highly mobile and contains all the necessary facilities for ordinary field maintenance of a routine nature. It is equipped with work benches, tools, jigs,

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and fixtures necessary to the maintenance, repair, and adjustment of optical and nonoptical fire control instruments.

b. The benches of the truck are of all-metal construction with hardwood tops. Under the benches are shelves and drawers for the storage of tools and fixtures. They provide approximately 34 square feet of bench space.

c. Tools consist of instrument repair kits for the individual repairman, general hand tools for shop use, machine tools, special tools, jigs, and fixtures.

d. The lathe on the instrument repair truck is a precision lathe, back geared and screw cutting. Its approximate size is 20 inches between centers with a 9-inch swing.

e. The drill press is belt-driven, ¼-inch capacity, with adjustable speeds to provide the necessary speeds for small drill use. The spindle is sensitive and well balanced.

f. The grinder is of the bench type, though not mounted to the bench, in order to permit its use outside of the truck so that the emery dust will not be free in the interior of the truck with the consequent possibility of injury to delicate optical elements. It has a fine and a coarse wheel.

g. The power for these machine tools is provided by a portable gas motor generating set, which can be placed outside of the truck when in operation and if conditions permit. It is light in weight and portable. It will deliver approximately 1½ kw. Power may also be utilized from the machine shop truck by means of portable cables. The machine shop truck has a much larger generating unit.

h. Light in the truck may be supplied by means of the portable generating unit, the machine shop truck, or any outside source of 110-volt, 60-cycle, alternating current supply which may be available.

i. There is a junction box on the outside of the truck which may be coupled to any 110-volt, 60-cycle, alternating current supply. This will supply the necessary power for the machine tools and lighting current if it is available.

6. Duties of personnel.—*a. Technical sergeant.*—This sergeant exercises supervision over the entire section. He allocates the work to other members of the section. He is responsible for the records of the work performed, proper maintenance of stock levels, and an adequate supply of spare parts and replacement instruments.

b. Staff sergeant.—This sergeant is the assistant section chief and assists the technical sergeant in the operation of the section. He supervises the work of the specialists and inspects the repaired in-

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struments. On occasion he, with one or two qualified specialists, may accompany parties from the artillery section for the purpose of adjusting, repairing, replacing, or inspecting instruments in the field.

c. Private.—There are 16 privates in the section who are specialists and perform such work as directed by higher authority.

d. Private, basic.—The two basic privates in the section are actually apprentices and will perform such work as is within their capabilities and knowledge and aid other members of the section as directed by higher authority.

7. Operations.—*a.* The maintenance operations of the instrument section include the following:

(1) Periodic inspection of instruments for adjustment and preventive maintenance operation.

(2) Adjustment and repair of instruments found defective by inspection or actual operation. If the facilities of the section do not permit satisfactory completion of the adjustment or repair, the unserviceable instruments will be passed on to a higher maintenance echelon. Replacement items should always be issued in such a case to the combat arm.

(3) Maintenance of a stock of replacement instruments in first-class condition.

(4) Preparation of instruments for storage if not required for immediate reissue and the cleaning and inspection of instruments in storage prior to issue to the using service.

(5) The rendering of such technical advice as may be necessary or requested to better enable the combat arms to keep items of fire control and sighting equipment in serviceable condition. Officers and noncommissioned officers charged with the responsibility of disseminating such technical information should be thoroughly familiar with the provisions of AR 45–30 and OFSB 4–8 and have a comprehensive knowledge of ordnance policies in general.

b. Instructions for the maintenance of instruments are given in the various Technical Manuals and other texts listed in this series.

8. Policies.—There is only one policy for the field maintenance operations of the instrument section. The work must be accomplished in the shortest possible time, in as efficient a manner as is possible. The sole mission of the instrument section is to keep the matériel they service in working condition. The using service must be kept supplied with an adequate number of fire control instruments to keep their troops at the peak of combat efficiency. When the nature of the adjustment or repair to be accomplished does not permit immediate

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reissue of the same instrument, a serviceable instrument will be issued. It is the responsibility of the section leader, or the senior member of the section in his absence, to see that all work is accomplished swiftly, efficiently, and in keeping with the standards of craftsmanship expected from ordnance personnel.

SECTION III

TRAINING OF INSTRUMENT SECTION

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9. General.—Prior to any actual assignment to the instrument section, the recruit will have completed his basic military training, and may or may not have received specialized instruction in the technical phases of his education. Since the present classification system contemplates the assignment of personnel so as to utilize to maximum advantage their previous experience in civil life, and takes into consideration the educational qualifications of each man, individuals assigned to the instrument section will probably require but a minimum of preliminary training.

10. Responsibility.—*a.* In large organizations it is customary for the senior commander to allocate the responsibility for technical training of the units or sections. If such a centralized training program exists, the section leader will receive detailed instructions for the carrying out of that portion of the main schedule which applies to his section.

b. In the absence of a coordinated central program, it is the responsibility of the section leader to see that personnel assigned to his section receive such instruction as is necessary to allow them to discharge their responsibilities. In such event, the section leader should lay out his own training schedule so as to take maximum advantage of the facilities and time available.

11. Instructors.—*a.* In the construction of such a training schedule, the section leader should take full advantage of the experience of those members of the section who may be qualified as instructors.

b. If the instrument section is in the field, any schedule contemplated must be planned so as not to interrupt the normal routine and duties of the section. If only a few untrained men are assigned to the section, they may be paired off with men of experience until qualified to work alone. This is not always satisfactory. A comprehensive group training schedule is conducive to more efficient results.

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c. If the recruits are to be trained as one or more groups, the instructors should be familiarized with the entire schedule and given ample facilities and room for their classes. Sufficient reference material should be made available as the schedule may require. Subjects should be assigned to instructors best qualified to instruct in them.

12. Training schedule.—*a.* The basic training of the instrument repairman can be divided into two units:

(1) *A solid groundwork of general information which can be given by lecture, demonstration, and text.*—This should not comprise more than one-quarter of the total amount of time allotted. It should include a brief course in the principles of elementary optics, elementary shop practice, and general information relative to the conduct and work of the instrument section, similar to that contained in this manual.

(2) *Specialized and detailed instruction in the maintenance of individual instruments.*—This phase of the apprentice's training should be practical in nature and consist entirely of work on actual instruments under the supervision of competent instructors. It should include a brief synopsis of the use, construction, operation, and nomenclature of each instrument, and a large proportion of time should be devoted to field inspection, disassembly and assembly, and repair and adjustment. For this phase of the training, representative instruments should be selected and instruction confined to them.

b. A sample training program is included in section XVI. It covers the basic training of the apprentice for a period of 3 months and is complete with recommended references for every phase of the instruction. This schedule may be modified to meet local conditions. When this becomes necessary, training should become specialized in nature, rather than eliminating the basic theory of the course.

13. Advanced training.—*a.* Time permitting, a more advanced system for the training of the instrument repairman should be devised. Once the basic technical training is acquired, however, the apprentice will gain confidence and experience through actual work and practical problems encountered.

b. No mention has been made of the training of antiaircraft fire control instrument specialists, since this is rapidly becoming a highly specialized branch of the instrument section's work and requires highly specialized training which cannot be given under ordinary field conditions.

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SECTION IV

DEFECTS AND CLEANING OF OPTICAL ELEMENTS

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14. General.—The function of any optical element is to transmit light by either reflection or refraction in accordance with a predetermined formula. No harm to the optical element can result from the mere transmission of light. It follows from this that the serviceable life of any optical element will be determined only by the care and consideration it receives and the conditions under which it is used. The cleaning of optical elements prolongs the life of the elements, renders them more efficient, and is one of the most important functions of the instrument section.

15. Moisture.—*a.* One of the important points to be observed in the care and preservation of optical elements is to prevent deposits of moisture from accumulating upon them by condensation from the atmosphere. The humidity of the atmosphere is one of the most potent agents in the production of the patina or film that is so often seen on lenses and prisms. The presence of this film will soon render the element unserviceable unless removed. The condensation of atmospheric moisture on optical elements occurs when the temperature of these parts is lower than the dew point.

b. The safeguarding of fire control instruments in storage against the ravages of moisture is discussed in paragraph 91.

c. The safeguarding of instruments in the hands of troops against the ravages of moisture is discussed in paragraph 90.

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d. When the presence of patina or film is detected by ordnance maintenance personnel of the instrument section on any optical element, it should be cleaned immediately in the manner prescribed in paragraph 27.

16. Chemical decomposition of optical glass.—*a.* Chemical decomposition of optical glass is caused and accelerated by the action of dust, moisture, and acid.

b. Decomposition usually appears initially on the exposed surfaces of the objective and eye lenses of an instrument. It may appear, however, on any surface, and being indiscriminate in action, it attacks both the crown and flint types of optical glass.

(1) Water may be taken into composition on the surface layers of the glass and the alkaline content of the glass set free. There occurs during this reaction a progressive disintegration deleterious to the quality of the optical glass. The resistance of the glass to this decomposition depends upon its composition. Water present on the glass may enter into a reaction with coexistent dust and form weak organic acids. Organic acids are injurious to the glass and accelerate its chemical decomposition.

(2) Acetic and uric acids usually present in perspiration are equally injurious. This is the reason that perspiration is so undesirable on the fingers of the specialist engaged in the cleaning of optical components. The touching of the bare fingers to the surface of any optical element should always be avoided.

(3) Decomposition of glass by weathering is due to the action of dust and moisture in the atmosphere, resulting in conditions similar to those described in (1) above. This type of decomposition is accelerated by extreme temperatures and sudden changes in temperature. Even greater precautions must be taken to safeguard optical elements in tropical climates than ordinarily, to avoid the formation of moisture.

(4) Decomposition by weathering is called "lead spotting." It can be seen as a formation of brown spots, irregular in outline, on the surface of the lens or prism. In more advanced cases, the entire surface of the optical element may be covered with a dark film.

17. Inspection for chemical decomposition.—*a.* The surface decomposition detracts from the efficiency of an optical element by reducing the amount of light that can be transmitted by that element. To observe the minor phases, or the beginning of this condition, hold the optical element to be examined so that bright light from its surface is reflected into the eye. Focus the eye on the glass surface. With a little practice the ability to detect lead spotting in its formative stages on any surface of the element will be easily acquired.

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b. To observe the various surfaces of optical elements when they are assembled in an instrument, they can be seen quite easily by looking through the objective end of the instrument. Any surface of any optical element that is between the objective lens and its focal plane can be distinguished with ease.

c. To observe the surface of optical elements that lie between the eyelens and the reticle, a magnifying glass held in rear of the eyelens, and moved to bring the desired surfaces into view, will be found of great value. The eyelens itself can be viewed by the use of reflected light in the manner described in *a* above. The reticle can be observed quite distinctly, since it lies in the focal plane of the objective, by looking through the instrument in the normal manner.

18. Deterioration of adhesive balsam.—*a.* Compound lenses or prisms are optical elements that consist of two or more similar or dissimilar elements cemented together, with their optical axes in correct alinement. Canada balsam is the adhesive agent employed for this purpose. It is specially refined to eliminate all traces of turpentine and other impurities.

b. The Canada balsam used for cementing purposes on compound lenses and prisms sometimes becomes dry, crystallized, or deteriorated to such an extent that the amount of light transmitted by the element is seriously diminished.

c. This condition is easily recognizable by a delicately formed tracery of varied hues not unlike the appearance of a film of oil upon water. This effect is noticeable in the lens or prism being inspected. Frequently evidence of the deterioration may be like frost crystals or small round disks in the form of numerous concentric circles. Rarely, it may be a dull brown film. Under any condition, it is always easily seen.

d. Eventually, these spots and discolorations will grow in size and render the elements concerned completely unserviceable.

e. The cleaning and cementing of this defect is not a function of the instrument section in the field. Field maintenance consists of replacement of the elements concerned. The recementing of compound lenses and prisms is an arsenal function.

19. Bacteria.—Under certain conditions bacteria may collect and grow upon the surfaces of lenses and prisms. Usually this occurs to instruments in storage for long periods of time. The condition especially applies to tropical climates. It can be greatly retarded by proper precautions and by keeping the lenses and prisms concerned clean and dry.

20. Seeds, bubbles, stones, and striae.—*a.* Defects that may by present in lenses and prisms under certain conditions include seeds,

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bubbles, stones, and striae. These are caused by faulty methods of manufacture. They are usually detected prior to being placed in service. Occasionally one may be found in an instrument. If it makes the instrument unserviceable, it should be taken out of service and replaced with a serviceable lens or prism.

b. Stones are due to the solid material that may inadvertently get into the molten glass at the time of manufacture. Bubbles are air pockets in the glass. . Seeds are similar to these air pockets, being very minute bubbles in the glass. All of these defects can be detected quite easily by careful observation and inspection. Indirect illumination or diffused reflection will show them up by making them appear brighter than the immediate surroundings.

c. Striae and strain are most easily observed by their resemblance to wavy bands which appear to be of different density and color than the surrounding medium.

21. Other lens imperfections.—Such strictly optical aberrations as coma, curvature of field, astigmatism, spherical aberration, chromatic aberration, and distortion are seldom encountered in lenses of good manufacture. When encountered, replacement of the element concerned will be necessary.

22. Silvered surfaces.—*a.* Silvered surfaces on glass are known as mirrors. They are used to reflect light for various purposes. Such a mirrored surface consists of a coating of silver placed on the back of a glass element and protected by a finishing coat or cover of varnish or other preservative. When this coating becomes scratched, tarnished, broken, or ineffective because of chemical decomposition, the silvered portion of the mirror quickly breaks down, and the amount of light that is reflected is proportionately diminished.

b. This condition can best be detected by looking at light reflected by the mirrored surface. If the surface has deteriorated to any appreciable extent, it will have a scaled or brown and spotted appearance. The backs of mirrored surfaces must be carefully handled, since the protective coating which is applied to the silver is generally paint, lacquer, varnish, or wax. The better surfaces have a metallic protective coat. Once the protective coating, regardless of its nature, becomes marred or broken, deterioration quickly sets in.

c. Mirrors and prisms with silvered surfaces are used to a great extent in many items of fire control and sighting equipment. All instrument repairmen should be familiar with their nature and defects.

23. Other defects.—There are other defects which can be found to occur in, or to, optical components. Most of them are too obvious for comment. Chipping, scratching, breakage, dirt, etc., are self-explanatory.

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24. Summary of defects.—The foregoing defects can be summarized by saying that the greatest contributing causes to defective optical glass are—

a. Carelessness in handling and a lack of knowledge concerning the precautions that are necessary.

b. Imperfections due to manufacture which are unavoidable and can be remedied only by replacement.

c. Chemical decomposition of the glass occasioned by the presence of dust, moisture, acids, etc., which can be retarded and avoided by proper care and cleaning.

d. Old age, which will eventually render any optical element unserviceable, regardless of the precautions which are observed by personnel for preservation.

25. Supplies required for cleaning optical elements.—When optical components require cleaning, the following supplies will be required for a complete and efficient operation:

Grain alcohol.
Camel's-hair brush.
Lens tissue paper.
Air bulb.
Jeweler's eye loupe.

26. Precautions to observe when cleaning optical elements.—*a.* Extreme care and good judgment must be exercised in the cleaning of optical elements. When lenses and prisms are removed from an instrument, they should be immediately marked for future identification and to insure correct positioning on replacement, and then thoroughly cleaned. After being cleaned, they should be wrapped carefully in lens tissue and laid safely away until the instrument is to be reassembled.

b. Upon the removal of a lens from an instrument, note the position that each side of the lens faces in the instrument. It is good practice to scribe or mark an arrow on the edge of the lens to indicate the direction it faces. The arrow should be used in a uniform manner. It is customary to have it point toward the objective end of the instrument. Lenses and prisms may be so marked on the unpolished surfaces or edges by the use of a diamond point or indelible pencil. If a pencil is used, care must be taken not to remove the mark during the cleaning operation. On reassembly, preserve the original relationship of all optical surfaces.

c. When removing or replacing lenses in their cells, do not bring too much pressure to bear upon them. They are usually snugly seated in these cells. After the retaining ring has been removed, crumple lens-

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cleaning paper into the cell next to the lens; turn the cell over; and press *gently* on the lens with a piece of lens paper between the lens and the finger tips. Immediately clean the lens after removal in this manner, wrap carefully, and lay aside in a safe place till reassembly

d. In removing prisms from their holders and seats, care must be taken not to apply excess force for removal. Immediately mark on the unpolished surface or side such identifying marks as "right," "left," "top," "bottom," etc. so as to allow replacement of the prism to the same relative position from which it was removed. Avoid anything that may chip or scratch any part of the prism. Clean, wrap, and lay aside.

e. Some objective lenses are not cemented. In all such cases, lenses of this type should not be removed from their cell. If it does become necessary to remove them, do so without changing their relationship to each other; immediately mark the two elements so that they can be correctly realined when replaced. If doubt exists as to the position of the lenses prior to removal, reference should be made to the drawings of the instrument concerned.

f. Some lenses are burnished into their cells. Under no conditions will these be removed for cleaning. In an assembly of this type, the lenses should be cleaned in their cells. They must not be removed.

g. Extreme care must be exercised in the cleaning of reticles. Any scratch, mar, mark, speck of dirt, etc., on the surface of a reticle will be magnified according to the power of the instrument, since the reticle lies in the focal plane of the objective and the eyepiece assembly. The reticle is always the most difficult element to clean in any instrument. It may require hours to complete the job satisfactorily. Extreme patience must be observed.

h. Always bear in mind that the passage of light through a lens or prism does not damage these elements. Existing defects, in practically all cases, are the fault of the user or repairman, and can be attributed to either lack of knowledge or carelessness.

i. The precautions enumerated can be briefly summarized as follows:

(1) Never lay a lens or prism down on a surface of any kind unless it is wrapped and protected by several layers of lens tissue paper.

(2) Never leave an optical element lying around unwrapped and unprotected. Always wrap and put in a safe place.

(3) Never touch any polished surface with the bare fingers. Never touch any surface with tools. Allow as little chance as possible for dust and dirt to accumulate on optical surfaces.

(4) Oil should never come into contact with any lens or prism.

27. Cleaning optical elements.—*a.* Lenses and prisms that are extremely dirty and have begun to crystallize with a film of dirt may

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be brushed with a clean camel's-hair brush under running water. The water should be at room temperature and should have but little force to it. *Never use hot water.* Brush the camel's-hair brush lightly across the lens until all of the surface film has been removed. Never clean cemented or compound lenses or prisms in this manner. If a cemented lens or prism is excessively dirty, use a wet brush to remove the grit and dirt. Observe every precaution to see that the water does not come into contact with the cemented edges of the lens or prism.

b. If lenses are dusty, first remove the dust with an air bulb and a camel's-hair brush before cleaning with lens paper and alcohol.

c. After the surface dust and dirt has been removed by the method described above, moisten the polished surfaces (one at a time) with a small amount of grain alcohol. It may be applied a little at a time directly to the surface or by moistening lens paper with alcohol and applying it indirectly. A perfume atomizer may be improvised to excellent advantage for spraying small amounts of alcohol.

d. Clean the surface by polishing *gently.* Use lens tissue for this operation. Repeat as many times as may be necessary to remove every trace of dirt, dust, stains, etc. Finish by polishing the lens or prism surface with clean lens tissue to remove streaks that may be caused by the alcohol. Do not be afraid to use plenty of lens tissue paper.

e. Never use the same piece of lens paper twice. Always make sure there are several folds of it between your fingertips and the optical component being cleaned. When rubbing, rub gently, and not too vigorously, to prevent marring or scratching the surfaces. Remember that the surface is being *polished* and *not ground.*

f. Always make sure that the lens paper being used is clean and free from dust and dirt which may have an abrasive action. Many small scratches are caused by dirty lens paper.

28. Finishing.—*a.* After polishing the surfaces a certain amount of dust and lint will still be perceptible. This can be blown off with an air bulb. After this is accomplished, inspect the surface for lint and dust by careful use of a jeweler's eye loupe. Look at the element being cleaned from every conceivable angle. A *clean* camel's-hair brush may be used to flick off small remaining bits of lint and dust.

b. Camel's-hair brushes used for cleaning operations with optical elements must be clean. They should be washed frequently in alcohol and dried throughly prior to use. Keep the bristles away from dusty surfaces. Do not touch the brush with the fingers. It is an excellent practice to wrap the brush in a piece of lintless paper when not in use. Never set the brush in water.

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c. When a lens or prism has been thoroughly cleaned, and inspection indicates satisfactory results, it should be placed carefully aside, wrapped and protected, if not being immediately replaced in an instrument.

29. Cleaning optical elements in their cells.—*a.* Lenses may be cleaned in their cells by wrapping a strip of lens paper around the end of a soft wood stick, making a swab. The paper should be cut, for this purpose, about 2 inches wide and from 6 to 8 inches in length. Wrap the strips obtained around a smooth, straight wooden stick about $\frac{5}{16}$ inch thick, and as long as may be deemed necessary. Make sure that the wrapping completely covers the end of the stick. This is to prevent the stick from coming into direct contact with the surfaces to be cleaned.

b. The swab, constructed in this manner, may first be used dampened with alcohol to clean the polished surfaces. Then, by removing the wet paper and replacing with dry paper that is clean, the polishing can be accomplished. Use plenty of clean strips of paper. Never exert excessive pressure.

c. Care must be taken not to use an excess amount of alcohol. It may run down onto the cemented edges and cause deterioration of the adhesive cement. Canada balsam is soluble in alcohol.

30. Vacuum systems.—*a.* A vacuum system, if available, is excellent for the removal of dust and lint from the surfaces of lenses, prisms, and reticles. Strips of lens tissue paper must be wrapped around the nozzles of the vacuum attachment to prevent the nozzle of the vacuum hose from touching polished surfaces.

b. By wrapping lens tissue around the stem of the manually operated air bulb, holding the nozzle over the surface to be cleaned, after suddenly expelling air from bulb, and then allowing the bulb to inflate, a vacuum effect can be achieved which will give satisfactory results.

31. Cleanliness.—Cleanliness of person is essential to successful cleaning of optical elements. Work should be accomplished in a dust-free atmosphere. Tools, work benches, floors, etc., should be clean and neat, free of oil, etc. The hands of the specialist should be clean. Hands should be washed in cold water prior to cleaning optical components, as this tends to close the pores, reducing perspiration. They should be dried thoroughly.

32. Summary of cleaning operations.—Certain rules for the cleaning of optical elements can be summarized and stated succinctly as follows:

a. Personal cleanliness is essential to an efficient job.

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b. Handle optical elements with care, and only by unpolished surfaces. Never allow bare fingertips to touch polished surfaces.

c. Lenses, prisms, and reticles should always be marked to insure correct positioning on reassembly.

d. All rubbing and polishing should be done lightly and gently.

e. Do not use alcohol to excess in the cleaning of optical elements.

f. Keep alcohol from coming into contact with the edges of compound lenses and prisms.

g. Lenses and prisms should always be wrapped and protected.

h. The air bulb should be used to remove dust.

i. Never force lenses into or out of their cells.

j. Never use metal tools to loosen or seat prisms or lenses.

k. Never clean optical elements with dirty cloth or paper.

l. Use only authorized cleaning materials.

m. Know what to do and the best way to do it.

SECTION V

CLEANING OF METAL COMPONENTS

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33. General.—The cleaning of metal parts is more or less taken for granted by the average repairman. This is a mistaken attitude and it is not conducive to efficient work. The proper cleaning of the metals parts of an instrument is as important as any other operation the repairman performs. No operation can be regarded as unimportant in the cleaning and servicing of a fire control instrument.

34. Reasons for cleaning metal parts.—The correct and thorough cleaning of metal components is important for many reasons. It is necessary that metal parts be cleaned before they can be properly lubricated and assembled. Cleaning retards chemical decomposition and premature deterioration. It minimizes the possibility of rust. Parts improperly cleaned may allow dirt, dust, and other foreign matters to get into the interior of the instrument where they may cause serious damage.

35. Safety precautions.—The provisions of Ordnance Field Safety Bulletin No. 7 must be complied with by all personnel. The following extract from OFSB 7 is reproduced here for the information and guidance of the instrument repairman:

Gasoline will not be used for cleaning purposes. SOLVENT, dry cleaning, Federal Specifications ES-661, SNL K-1, 2a, will be used in all cases where such

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a solvent is required. It should be remembered, however, that dry cleaning solvent is inflammable, its principal difference from gasoline in this respect being that its flash point is lower, approximating that of kerosene. In handling dry cleaning solvent, the precautions outlined in AR 850–20 will be observed.

36. Cleaning metal components.—*a. Ordinary cleaning.*—If it is a straight cleaning operation, immerse the part to be cleaned in dry-cleaning solvent, *making sure that all optical elements have first been removed.* Clean with a stiff-bristled brush, the size of which will be determined by the size and nature of the part being cleaned. Remove the part from the solvent, dry thoroughly, and replace as soon as practicable. Always be sure that the solvent is clean to start with. Never allow it to become saturated with old oil, grease, or dirt. Change the solvent frequently.

b. Heavy oil removal.—(1) Heavy oil and grease can be removed by the use of cleaning compound. See SNL K–1 and TM 9–850. Oil is removed by a process of emulsification in which the oil is broken up into minute globules. The adhesive properties of the oil are thus destroyed so that it can be readily rinsed from the surface being cleaned. Cleaning compound is usually used for the cleaning of parts which have been heavily coated with rust preventive compound, or heavy grease.

(2) For cleaning caked grease from metal parts, the compound in water solution is placed in a tank, preferably heated by a steam coil, and the parts boiled for 10 minutes or longer.

(3) Cleaning compound should not be used for small and delicate parts.

c. Removal of paint and varnish.—(1) The removal of paint and varnish can best be accomplished by use of paint and varnish remover. See TM 9–850.

(2) Paint and varnish remover should be applied as it comes from the can, very liberally, but slowly, with a 4/0 or 6/0 varnish brush, using a single or one-way stroke only. Brushing out or over several times seems to seal the surface so that the remover does not have its best effect. Allow the remover to stay on until the paint or varnish can be scraped or wiped off. Do not start scraping before it is loose. Wash *all* the paint and varnish remover off with dry-cleaning solvent before applying new paint. Wash the brush thoroughly with dry-cleaning solvent, and dry it before putting it into fresh paint or varnish.

(3) Keep paint remover out of any finished joint or bearing from which it cannot be thoroughly cleaned. It attacks rubber and should be kept away from insulated wires. It is well not to get any of the

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remover on the hands, as most brands have poisonous qualities tending to produce rash as well as dried and cracked skin.

(4) *Under no conditions ever attempt the removal of paint and varnish without first removing all optical elements from the piece being cleaned.*

(5) The remover is very flammable. Therefore *no smoking* will be permitted while it is being used.

SECTION VI

LUBRICATION OF FIRE CONTROL INSTRUMENTS

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37. General.—Wherever there is friction there is wear. Lubrication has as its function the elimination of wear. A secondary function is to permit free and easy movement of parts. Consequently, all moving parts require lubrication. In fire control instruments, the allowable tolerances, or play, between parts are very small. The smaller the tolerances, the greater will be the wear between moving elements. Also, when two surfaces fit together very closely, there is little room for a lubricant. If the surfaces are not true, the lubricant will be unequally distributed. Metal-to-metal contact can be prevented by the use of an appropriate lubricating material.

38. Lubrication.—Lubrication consists of the use of some substance which will dissipate the friction produced, thus absorbing the metal-to-metal contact within itself as heat energy. The lubrication of fire control instruments is complicated by the fact that overlubrication is dangerous to the delicate optical components of the instrument.

39. Precautions.—The greatest care must be exercised in the lubrication of fire control instruments to see that—

a. Too much lubricant is not applied.

b. The proper, authorized lubricant is used.

c. *All* the necessary parts are lubricated correctly.

40. Lubricants.—*a.* All parts of fire control instruments for which solid or semifluid greases and petroleum have been recommended will be lubricated with grease, special, low temperature, which has been selected for its exceptional low temperature characteristics. Grease,

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special, low temperature, is available in 8-ounce tubes and will be obtained by requisition from the following arsenals:

Rock Island Arsenal.	Augusta Arsenal.
San Antonio Arsenal.	Raritan Arsenal.
Benicia Arsenal.	Frankford Arsenal.

b. All parts of fire control instruments requiring oil will be lubricated with oil, lubricating, for aircraft instruments and machine guns, meeting U. S. Army Specification No. 2–27 of the latest issue in effect at the time of purchase.

c. Lubricants for fire control instruments function also as rust preventives. It is important that they be applied carefully and diligently. Extreme care must be taken not to overlubricate fire control instruments.

41. Use of lubricants.—Authorized lubricants will be used in the lubrication of fire control instruments and all their parts. The lubricant may be applied with the fingers, or in any other practical manner conducive to the best results. Wipe off excess lubricant. Prior to assembling the instrument, and after lubrication, be sure to wash lubricants off the person.

42. Lubrication of focusing nuts.—*a.* If a focusing nut, on being lubricated with grease, special, low temperature, is still too loose, a drop or two of viscous oil will tighten the movement. If the focusing nut is too tight, it can be worked down with pumice and oil. When this is done, be sure to wash it thoroughly prior to lubrication. The same care must be observed not to overlubricate.

b. When replacing focusing nuts or eyepiece sleeves on an instrument, care should be exercised to produce a smooth-running movement in the sextuple threads. If they bind, it may be necessary to run them in with powdered pumice and oil. Wash them thoroughly after this operation, and be sure that *all* of the pumice has been removed from the threads. Apply an even coat of grease, special, low temperature, to both pieces and inspect for smooth movement. Repeat the operation until satisfied. Eyepiece tubes and drawtubes of the battery commander's telescope may be treated in a similar manner.

43. Lubrication of throwout mechanisms.—Binding may occur to throwout mechanisms of instruments equipped with them. Determine which parts are at fault and take corrective action by removing all burs, high spots, etc. This may be done by the use of a scraper. When severe, the use of a fine file may be necessary. After this has been done, lubricate with grease, special, low temperature.

44. Miscellaneous.—Experience will soon familiarize the repairman with the "feel" of correct lubrication, once the basic fundamentals

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are understood. It is well to keep in mind that the most common error is to overlubricate. This must be avoided.

45. Summary.—*a.* Use only authorized lubricants. See OFSB 6–F–1 and SNL K–1.

b. Do not overlubricate.

c. Exercise extreme care in the application of lubricants.

d. Learn the "feel" of correct lubrication.

Section VII

SEALING OF FIRE CONTROL INSTRUMENTS

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46. Purpose.—Fire control instruments, more than any other type of ordnance matériel, are subject to extreme injury due to the ravages of severe temperature variations, moisture, grit, and the shock of rugged field conditions. Many other factors affect the adjustment and condition of the delicate optical and mechanical components of fire control instruments, in addition to those enumerated. Fire control instruments are constructed and designed to withstand these conditions. It is understood that *all* parts of every instrument cannot be thoroughly protected against *all* the ravages the instrument will encounter. However, certain things can be done which will minimize outside influences of a detrimental character. This is known as sealing. The sealing of fire control instruments has but one purpose, that is to keep as much moisture, dirt, and dust out of the interior of the instrument as possible. In this way the injury these things may accomplish is minimized. It is well to remember that effective sealing will do away with frequent disassembly for interior cleaning. The external parts of any instrument are easily cleaned. The interior is more difficult. The sealing of a fire control instrument must be effective, and the methods of sealing an instrument properly and thoroughly should comprise an integral and important phase of the instrument repairman's education.

47. Supplies available.—*a.* The sealing of fire control instruments is accomplished by appropriate use of certain authorized supplies to

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protect jointed parts, threaded members, etc., against the entrance of dust, dirt, and moisture. The supplies most commonly used are—

Plastelina.
Plugging cement.
Paint.
Grease, special, low temperature.
Shellac.
Black navy sealing compound.

b. These supplies are not interchangeable in use. Each is used for specific purposes. The instrument repairman should be familiar with the use of each, manner of application, and any substitutes which may be suitable for a similar use. He should realize the importance of effective sealing. If no sealing supplies are available, he should be able to improvise a suitable substitute. Instruments that are properly sealed will remain serviceable for years. Instruments improperly sealed will be back for repair within months. It is well to keep this fact in mind.

48. Plastelina.—Plastelina is ordinary modeler's wax. It should be used on parts where handling is at a minimum. It does an efficient job of sealing, remains soft for an extended period of time, and is easily removed. For this latter reason, however, it is impractical for sealing of adjusting screws, because of the tendency of would-be mechanics to remove the compound and tamper with the screws it is supposed to protect. It should be used only when a more effective sealing compound is not available.

49. Plugging cement.—Plugging cement (usually red) is used to plug the recesses above the heads of various adjusting screws, etc. It is the best material recommended for this purpose, and affords a tight, moistureproof, and dustproof seal. It dries to an exceedingly hard consistency, and is removed with difficulty. This is both an advantage and disadvantage. When it is desirable to hide completely, as well as seal, a screwhead, plugging cement of the same color as the surrounding part or body of the instrument should be used. Care must be exercised in application, as it is quite easy to smear the body and mar the finished quality and appearance of the work. By use of various pigments, the cement may be used in different shades and colors to match the finish of any particular instrument. (See TM 9–2603.)

50. Black navy sealing compound.—This is a black, putty-like compound widely used on all fire control and optical instruments. It is used primarily to seat and seal lenses and other optical components in their cells. It must be used with discrimination, and sparingly. Used to excess, it may smear and greatly harm the elements con-

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cerned. In extreme cases overapplication may eventually expand and crack the lenses it contacts, rendering them unserviceable. It should be applied very sparingly to the edge of the lenses being seated. There should be just enough to make the lens airtight and moisture-tight where it is seated in the cell, but not enough to overrun the lenses. It is the best sealing compound available for this purpose.

51. Sealing threaded parts.—Threaded parts should be sealed through the use of low temperature special grease. It should be applied sparingly, and care exercised to see that it does not come in contact with the optical components of the instrument.

52. Miscellaneous.—*a.* Ordinary putty, when colored to match its surroundings, is an excellent sealing compound. It may be used for short periods of time on those parts that require very little handling.

b. Painting, covered in detail in section VIII, has as a secondary function the sealing of the parts painted. It should not be relied on for the complete sealing of the parts concerned.

c. Shellac is used on screwheads. A drop or two will give an effective seal. They should be painted to match their surroundings after the application of shellac. *Shellac should never be used to seal threaded parts, or used on threads of any kind.*

53. Improvised sealing compounds.—*a.* Beeswax can be used to form the base of many improvised sealing compounds. Colored paint pigments can be utilized to furnish the desired hue or color. A good sealing compound for the heads of adjusting screws can be made in the following manner. Heat beeswax to a liquid state; add dry yellow ochre and dry red lead to produce a good color of the shade desired. Prussian blue or lampblack may be added to vary the color scheme. The mixture should be removed from the heat and stirred while cooling to keep the pigments in suspension.

b. An equally good compound can be made in an olive drab color by following the above procedure, but adding the settled pigment taken from the bottom of a can of issue olive-drab paint instead of the yellow ochre, red lead, etc.

c. If it ever becomes necessary to improvise a sealing compound, the following rules and precautions should be kept foremost in mind:

(1) Nothing that is harmful to metal or optical glass may be used.

(2) Nothing that may dry or harden to a brittle state should be used.

(3) Nothing that will soften and flow under direct sunlight may be used.

(4) Nothing that requires force or excavation for removal should be used. This would cause damage to associated parts.

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d. The pertinent facts to use as a guide in the sealing of an instrument are:

(1) A properly sealed instrument must be proof against the heaviest rain.

(2) A properly sealed instrument should be safe in a dust storm.

(3) It must stand the extreme temperature variations between tropical heat and polar frigidity.

(4) The sealing must be proof against the shocks, jars, and rough usage of strenuous field conditions.

(5) The sealing efficiency of the instrument must remain unimpaired in the face of any emergency that may develop.

54. Summary.—*a.* By the use of appropriate supplies, an instrument can be rendered dustproof and moistureproof.

b. One rule will suffice for a working guide. *Do not leave a single crack, joint, aperture, or screwhead unsealed when assembling an instrument.*

SECTION VIII

PAINTING OF FIRE CONTROL INSTRUMENTS

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55. General.—Painting of instruments should be understood thoroughly by all personnel of the instrument section. Proper painting of instruments is important for two primary reasons:

a. Proper painting materially prolongs the serviceable life of the instrument by acting as a secondary sealing agent in preventing dirt, dust, and moisture from entering the instrument.

b. Proper painting adds to the general appearance of the instrument.

56. Precautions.—Occasionally there are received at the arsenals for repair, instruments which indicate that the malfunctioning of various mechanisms is due to excessive paint having entered bearings and bearing surfaces and having splashed on scales and lenses. The effects of paint on bearing surfaces and in bearings is obvious. The removal of paint from scales and lenses has resulted in the scratching of scales and damage to the lenses. In order to eliminate the conditions described above, the painting of fire control instruments by the using service is prohibited. The painting of instruments, when

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done by ordnance personnel, must be supervised by someone who is familiar with the functioning of the instruments and who is in a position to caution against the application of paint to scales, lenses, bearing surfaces, sight seats, etc. The paint required will be governed by the instrument to be serviced.

57. Brushes for painting.—*a. Care of brushes.*—The bristles of brushes are subject to attack by moths and should be protected by naphthalene while in storage. Camel's-hair brushes, after being thoroughly cleaned with turpentine, should be laid flat on a horizontal surface. All other brushes should be thoroughly cleaned in turpentine and kept with their bristles submerged in water. The proper care and efficient cleaning of paint brushes, after using, are indicative of a smoothly functioning and efficient section.

b. Types of brushes that are standard for issue.—(1) Brush, mottling, No. 2 (⅞-inch). Bristles project about 1 inch from the brush, and the over-all length is about 5¼ inches. Used for cleaning sights and position finders, etc.

(2) Brush, artist, camel's-hair, round, No. 1. This brush is about 3/16 inch in diameter. It is used for cleaning the lenses of optical instruments, painting around oilholes, and for lacquering small surfaces. Never use the same brush interchangeably for these functions.

(3) Brush, dust, painter's, round, 2½-inch. This brush has about 3¾ inches of bristles exposed. It is used for cleaning surfaces prior to painting.

(4) Brush, paint, metal bound, flat, No. 3 (4-inch). This brush is used for painting large surfaces.

(5) Brush, sash tool, oval, No. 3, 27/32 by 1¾ inches. The bristles in this brush are laid to a chiseled edge. It is used for painting a narrow line, as on a window sash at the edge of the glass. It is also used as a grease brush on targets.

(6) Brush, varnish, flat, double X thickness, No. 2 (1½-inch). This brush is used for general painting and varnishing.

(7) Brush, varnish, oval, 1⅞-inch. This brush is chiseled on both sides. Used for general painting and varnishing work.

c. Use of brushes.—Be sure that all brushes are clean prior to use. The size of brush selected for any particular job is very important. This selection should be guided by the size of the part to be painted and the nature of the work to be done. Brushes must be thoroughly cleaned after using.

58. Paints.—*a. Lusterless olive-drab synthetic enamel.*—For metals the finish shall consist of two coats of lusterless enamel over one coat of a rust-inhibiting synthetic primer. For nonmetals the finish shall

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consist of two coats of enamel over the primer. For metals, apply one coat of primer, synthetic, rust-inhibiting, USQMC Specification ES No. 359, and air-dry for 6 hours. Apply one coat of lusterless enamel and air-dry at least 30 minutes. Then apply the second coat of lusterless enamel and air-dry for 12 hours. For nonmetals apply one coat of primer, ground, synthetic, USQMC Specification ES No. 360, and air-dry for 6 hours. Apply one coat of lusterless enamel and air-dry for at least 30 minutes and then apply the second coat of lusterless enamel and air-dry for 12 hours.

b. Clear lacquer.—Apply one coat of nitrocellulose lacquer and air-dry. Apply one or two coats of shellac lacquer, as required for an even finish. Air-dry each coat.

c. White enamel (air-dry).—Apply one coat of flat white and air-dry. Apply one or two coats of the highest quality 4-hour air-drying enamel, as required for an even finish. Air-dry each coat.

d. Orange gum shellac varnish (for wood).—Apply two coats of orange gum shellac varnish, allowing each to air-dry.

e. Shellacs.—(1) Orange shellac is used to seal the joints of optical instruments (in shops only) and for finishing the inside of wooden chests, etc.

(2) White shellac is a quick-drying, light and transparent body varnish which is not issued, except in special cases, and then only to repair shops. It is used on plotting, range, and deflection boards as a protection against moisture.

(3) Shellacs seal surfaces quickly, but do not stand the weather as well as varnish. They are not as transparent as cellulose-nitrate lacquer, unless very highly refined. Their use is governed by these qualities. Pure grain alcohol is the best thinner to use in them. The white shellac is materially darkened by contact with iron, and, where color is important, should be kept in glass and spread with a brush bound with leather or rubber rather than with tin plate.

f. Scale filler.—Scale fillers are of different colors. The color most commonly used is white. Only colors identical with those authorized may be used. The authorized color of a scale cannot be changed, and if it were changed it would constitute an unauthorized modification in direct violation of Army Regulations. Scale fillers are available as follows:

(1) White.
(2) Black.
(3) Deep vermilion.
(4) Translucent white.

For scale fillers (1), (2), and (3) above, first clean and repaint scale plate the desired color and allow to dry thoroughly. Then rub or

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brush the required filling into the graduations which should have been previously rendered clear-cut and distinct. Rub off surplus filling; wash with castile soap and water; rinse in clean water; and dry. Check to see that the job is neat and legible. To apply scale filler (4), translucent white, clean the face of the scale or dial, repaint, and let dry. Remove all paint from perforations or graduations with a scriber or other appropriate tool. Be sure that all edges are left sharp and distinct. Fill the perforations or graduations by applying the filler with a brush to the back of the scale or dial. Air-dry and retouch for air bubbles and other defects. Check to see that the job is neat and legible. When special fillers are not available, a neat and workmanlike job may be accomplished by use of an improvised or emergency scale filler. A good white scale filler can be made with ordinary white lead paint. It should be about the consistency of putty and may be applied as described above. Other colors can be obtained by use of various pigments. Care must be exercised to see that the color will match the authorized color for the part to be serviced. It should be noted that not all scales are painted. Some have graduations etched into the metal. Prior to servicing perforations on this type of scale the metal should be thoroughly cleaned. The scales should not be painted unless it is so stated in the specifications for the instrument. Refer to drawings or U. S. Army Specification when in doubt.

59. Preparation of surfaces to be painted.—All surfaces to be painted must be dry and free of dirt, oil, grease, and rust. See paragraph 36*c* for instructions on removal of paint and varnish.

a. All metal surfaces will be cleaned before being painted by one of the following methods:

(1) Thoroughly wash parts in dry-cleaning solvent and thoroughly rinse with hot water. Dry in an air stream. It must be remembered that frequent washing of metal components in the same batch of solvent will soon render it unfit for further use, since it easily becomes saturated with grease, oil, and dirt. The solvent must be changed frequently. Rough, sand-cast surfaces to be finished will be rough-filed or ground to remove all projections that will result in a poor finish.

(2) All metal surfaces to be painted, except anodically treated aluminum, will be sandblasted with fine shore-bar sand.

b. All wood surfaces will be dry and sandpapered smooth before applying the paint.

60. Applying paint.—Paints may be applied to fire control instruments with either a spray or a brush. Parts that are to be covered completely with paint may be dipped in accordance with the best

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practice. The exact procedure to be followed will rest on the judgment of the section leader, who will keep the factors listed below in mind while making his decision.

a. General requirements.—The following general requirements should be kept in mind by the section leader at all times, as well as by personnel actively engaged in the painting of instruments.

(1) Finished colors must match authorized or prescribed hues. Minor deviations of pigment proportions are permissible, if necessary to match colors.

(2) Interior surfaces of instruments should never be painted unless specified on drawings.

(3) The interior of telescopes will be sandblasted and given one coat of drop black, ground in japan, and thinned with turpentine. All grease should be removed from graduated surfaces by washing with dry-cleaning solvent, after which the surface should be sandblasted slightly and two coats of shellac lacquer applied.

(4) Oil fittings, grease cups, plugs, etc., will be painted with red enamel. Oilholes without plugs or other means of closing will have a red circle painted around them in order that they may be readily located.

(5) All visible headless screws will be plugged and painted so as to render them invisible.

(6) Extreme care must be exercised to avoid splashing paint on parts which are not to be painted.

(7) The detailed requirements for any particular instruments can be found in the appropriate manuals or on pertinent drawings.

(8) On completion of all painting and finishing operations, the instrument serviced should be thoroughly inspected by the section leader or his assistant. An unsatisfactory paint job should never be allowed to leave the shop.

b. Varnishes and enamels.—Varnishes and enamels should be stirred well before using. If too thick they should be thinned with turpentine but never to the extent that the varnish or enamel does not cover. The exact and proper thickness of each coat can be learned only from experience. If it is too thin it often cracks in drying, while if it is too thick it becomes blistered, wrinkled, and uneven. The first coat, however, may be much thinner than each succeeding one. After repeated paintings, the paint may become so thick as to scale off in spots. It may be then removed by the use of the authorized remover aided by a paint scraper where practicable. Before painting wood, fill all cracks and crevices with putty. Remove excess with sandpaper.

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c. Paint driers.—There are two general types of paint driers: japan drier, containing gums or resin; straight oil driers, not containing gum. The issue of japan drier is restricted to special conditions. Driers are used in paints to hasten the drying of the linseed oil base which would otherwise dry very slowly. Driers, and in a less degree, turpentine, operate through their ability to absorb oxygen from the air and to transmit this oxygen to the linseed oil. Too much drier "burns" paint, causing it to get too hard and to scale. Ready-mixed paints have the correct amount of drier in them, and no more should be added unless the paint is so old and thick that a comparatively large volume of linseed oil is necessary to thin it. Driers should never be used to thin paints, nor should more than 1 percent by volume be used in any case.

SECTION IX

INSPECTION METHODS AND FORMS

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61. Purpose of periodic inspection.—All ordnance matériel must be inspected annually if it is in active service or post storage. The latter may be subjected to only a percentage inspection. The purpose of this annual inspection is threefold:

a. To assure that all matériel is in serviceable condition.

b. To allow for the correction or minor defects at the time of the inspections.

c. To allow for the application of any authorized modifications that may have been ordered and not yet applied.

62. Inspection detail.—As a general rule orders for the annual inspection of matériel are issued by the corps area ordnance officer who directs that the ——— section of the ——— ordnance company will proceed to the stations indicated, remain at such stations for the period of time indicated, for the purpose of inspecting and repairing the ——— matériel at said station, and will upon completion of the aforementioned duties return to their home station.

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63. Time allotted.—The amount of time allotted is usually elastic. If the time required to complete the inspection should exceed the amount of time specified in the order, the remaining stations on the inspection itinerary are notified, either by an informal note to the post sergeant major or by the use of official channels of communication. The same rule applies should the work be completed ahead of schedule. The necessity for this procedure should be anticipated a day or two in advance to avoid last minute complications.

64. Duties of section chief.—*a.* When the section receives orders for the trip, it is the duty of the section chief to ascertain the type and quantity of the matériel to be serviced. He must make up a set of basic spare parts in anticipation of needs as evidenced by his estimate. Extreme care must be exercised in the selection of these spare parts. Since there is no publication on which this set can be based, experience must point the way for quantities to be taken, unless standardized sets of spare parts are available, as may be the case for certain types of matériel.

b. A cabinet should be provided to carry the spare parts. All parts should be plainly marked with their correct nomenclature and drawing numbers. They should be conveniently arranged in the cabinet. A list of the spare parts packed for the trip should be prepared to show not only quantity but location of each in the cabinet. The parts expended should be posted to this record. If properly kept, such a list will give an accurate record of the number of parts used and those left on hand.

c. The special ordnance tactical vehicle that is to be used should be gone over with the greatest of care. All tools, jigs, and fixtures should be checked to see that they are complete, serviceable, and in their proper places. Everything should be conveniently placed and fastened down in what is known as "march order."

d. It is not anticipated that the entire section will make the trip. At least one qualified man should be left at the home station to take care of any work that may turn up during the absence of the rest of the section.

e. The chief of section should secure road maps of the area to be traversed and in which the section will operate, and plan the best and shortest route between various points. Keep in mind, however, that the best route is not always the shortest. The quantity of traffic and the quality of the roads are two factors that should always influence the final decision.

f. Upon arrival at the various stations, the chief of section should report to the post sergeant major and present a copy of his orders.

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The sergeant major will then make the necessary arrangements for rationing and quartering the detail.

g. Organizations to be inspected should be notified in advance and a schedule worked out for the time and the place of the inspection. Due consideration should be given the organization training schedule so as not to interfere with training in progress at the time of inspection. When it is not possible to arrange satisfactory schedules for the inspection of the ordnance matériel belonging to an organization, steps should be taken to issue replacement equipment, assuming such equipment is available. This should be a temporary expedient, and immediately after inspection the original equipment of the organization should be reissued.

h. When more than one person is on the inspection detail, the chief of section should assign each individual appropriate duties to be performed during the course of the inspection. It is good practice to have a specialist make the actual inspection. The chief of section is then available to coordinate the entire inspection program, and free to make any decisions that may be required. The chief of section should keep a close eye on the work of his specialists, frequently checking the results of their inspection.

65. Blank forms.—*a. Instructions.*—The inspection reports and blank forms are included in O. O. F. 7228 and O. O. F. 7229. The instruction sheet will outline the general policy of the Ordnance Department concerning the entries to be made. O. O. F. 7228 will be used to record the final results of the inspection and will be distributed as follows:

(1) Original copy retained by inspecting party for corps area commander.

(2) One copy to the commanding officer of the organization inspected.

(3) Such additional copies will be made as are required.

b. Unusual conditions or glaring deficiencies will be reported separately, if of such magnitude as to require special action.

66. Action to be taken.—*a.* As items of ordnance matériel are inspected the results must be entered on the inspection form and the proper disposition and action taken or recommended in the case of each separate item. Each item should be entered on the form with its serial number. The disposition or action indicated or taken may fall into one or more of the following classifications:

(1) No defects, continue in service.

(2) Using service to make necessary correction.

(3) Repair or adjustment at time of inspection by ordnance specialist.

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(4) Exchange at local ordnance depot.

(5) Send to a local ordnance shop or other designated point for more extensive repair or adjustment than can be accomplished at the time of the inspection.

(6) Ship as instructed to depot or arsenal.

b. Abbreviated symbols for expressing these actions are included on various types of inspection forms. Inspection personnel should always indicate the action to be taken in the appropriate column of the inspection report. The value and purpose of the inspection are lost unless appropriate repairs or adjustments are made on the spot to correct existing defects, or, if this is impractical, the proper action indicated to render the matériel serviceable as soon as possible. It is the responsibility of the section chief or the chief inspector to see that the inspection forms are adequately and correctly filled out.

67. Removal of organizational equipment.—All equipment physically moved from the location of an organization should be covered by an informal receipt issued to the organization commander, noting thereon the specific item and serial number, its general condition, shortages of equipment or accessories, if any, and any serious damage that may exist to nonexpendable parts.

68. Inspection methods.—*a. General.*—Forms O. O. F. 7228 and O. O. F. 7229 are simplified inspection forms (see *e* below). Although these forms are standardized for use throughout the service, many other types are in use. These latter are usually extracted from the standard forms and supplemented with extra columns for additional entries. It must be remembered when deviating from the standard that the prime requisite of any inspection form is simplicity. The three following methods are suggested as uniform, simplified inspection forms and methods. They may be used in addition to the two standard forms discussed above. Forms shown in *e*(3) and (4) below should be drawn and reproduced in the field.

b. Complete report system.—This is for use primarily where the complete inspection of a number of items (as many as are listed on one page of the inspection report) precedes the repair work on these items. It utilizes a series of forms (*e*(3) below) each designed to cover a number of items of the same kind. The forms will normally be completed by a recorder from the data given him by the inspector. The original is normally completed in pencil, and one carbon copy will usually be sufficient. At the completion of the inspection the inspector indicates on the form the disposition of the unserviceable items. The carbon copy is left with the organization commander, and the original is delivered to the repair personnel. When the work is completed the repair organization sends the original to the corps area

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ordnance officer, or the information may be extracted and entered on O. O. F. 7228 or O. O. F. 7229 and sent to the corps area ordnance officer.

c. Ticket system.—This system is designed for use in those cases where each item is repaired immediately after it is inspected, and is especially valuable where a number of men are working on the same type of matériel. A different ticket (*e*(4) below) is printed for each type of matériel and the usual defects listed so that they may be checked off by the inspector or recorder. At the completion of the inspection of each item the ticket is attached thereto and sent with it to the repairman. In order to conserve time serial numbers may be recorded only when repairs cannot be made instantly, in which case the date of inspection and the initials of the inspector are recorded on the back of the form. If desired, tickets may be collected, and a consolidated report made later; otherwise a record is made on O. O. F. 7229 showing defects which cannot be repaired at the time. This system is simple and can be readily adapted to meet various situations of peace or war.

d. Short report system.—This may be used when the inspection and the repair are accomplished by the same individual, at the same time, and a more complete report is not desired. Notations are made only in the case of items which cannot be repaired at the same time, or when special comments are considered necessary. O. O. F. 7229 is satisfactory for this purpose.

e. Model forms.—(1) *O. O. F. 7228.*

INSTRUCTIONS FOR INSPECTION REPORTS

O. O. F. 7228

A. This form will be used in submitting reports of inspection required to be forwarded to organization commanders, adjutants general, and property and disbursing officers of the various States, and to the office of the Chief of Ordnance. The lined copy is intended for field use only.

B. This particular form applies to inspection of all ordnance matériel in groups A to H.

C. Detailed instructions as to method and scope of inspection to be made will be found in Technical Regulations, Ordnance Field Service Bulletin No. 4, and other ordnance publications.

D. The name of the item being inspected, including the model, manufacturer, year of manufacture, and such other data as may be necessary for proper identification should be entered under item, and written straight across the sheet.

E. In reports of matériel other than groups A and B, serial numbers of all matériel carrying serial numbers will be entered in first column.

F. Serial numbers of matériel in groups A and B will be entered only when noting defects or other causes requiring remedial action. Items not requiring action may be included by noting the number inspected with remark to the effect that their condition was found satisfactory.

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G. In making report of matériel other than groups A and B, all items required to make a complete unit will be entered on the same page as far as possible, for example, the gun, carriage, recuperator, and sight which together make one unit should be grouped together on report.

H. Under column "Action to be taken," such abbreviations may be used as desired, providing explanation of the abbreviations used is entered as a note on inspection form.

I. For rifles and pistols, the first line will show the number on hand and the number authorized in the organization inspected.

J. Data as to manometer tests of recoil mechanisms, which the using services are not allowed to adjust, star gage records, adjustments of sight M1901, and other data which is required to be furnished the ordnance office may be forwarded as enclosure to this report and need not be furnished to the using service.

(2) *O. O. F. 7229.*

O. O. F. 7229

INSPECTION OF ORDNANCE MATERIAL

Sheet No. _____

Organization _____ Date of inspection _____

Station _____ Inspected by _____

Organization commander _____

Item and serial number	Defects noted	Action to be taken

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(3) *OFM 211.*

OFM 211

INSPECTION REPORT

INSTRUMENTS OR SIGHTING EQUIPMENT

Org. _____ Sheet No. F _____

Serial number	Appearance	Scales	Focusing nut	Hinge movement	Optical elements	Adjustment	Sealing finish	Modifications	Accessories	Remarks	Action

X—Defective.
DV—Double vision.
P—Parallax.
#O—For organization action.

S—Shop repair (ordnance personnel).
E—Exchange when so instructed.
ARS—Ship as instructed.
R—Repaired by ordnance mechanic.

Instruments
OFM 211

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(4) *OFM 212.*

OFM 212

INSTRUMENTS AND SIGHTING EQUIPMENT

Item:

Serial No.:

	Condition	Action
Appearance		
Scales		
Focusing nut		
Hinge movement		
Optical elements		
Adjustment		
Sealing finish		
Modifications		
Accessories		

(Obverse)

Other defects:	Action

Organization

Inspector

Date

OFM 212

(Reverse)

69. Unforeseen situations.—The inspection party will occasionally encounter conditions and situations for which no preparations have been made. The main thing to keep in mind is that the purpose of an inspection is to *help* the using service. If at any time the advice of the inspection detail is not accepted by the local authorities, complaints should be entered on the inspection report. The corps area ordnance officer will take the necessary action. Complaints and dissatisfaction can be kept to a minimum by efficient service and courteous treatment.

70. Policy.—The policy of the inspection detail should always be to render the best service of which they are capable, and leave behind a feeling that their work has been well done. All concerned should be sorry to see the detail leave.

71. Summary.—This section may be briefly summarized as follows:

a. Take proper and sufficient spare parts.
b. Have truck and equipment shipshape.
c. Plan the best route *before* leaving home station.
d. Report to the proper authority upon arrival.

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e. Make arrangements convenient for *all* parties concerned.

f. Put out the best work of which the section is capable.

g. Keep complaints to a minimum.

h. Remember at all times that the inspection detail is functioning as a unit of the military service and should maintain standards of discipline and work in keeping with this fact.

SECTION X

LEVELS AND LEVEL VIALS

	Paragraph
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Description	73
Level holders	74
Types of level vials in use	75
Precautions in use and handling	76
Adjustments	77
To set level vials held by packing	78
To set level vials held by external screws	79
To adjust level vials held by internal screws	80

72. Definition.—A level is a device used to establish an accurate line or surface at right angles to the vertical. Depending on the mounting, it may also be used to establish a line perpendicular to the horizontal. The level is a device that is an essential component in most types of fire control and sighting equipment.

73. Description.—All levels consist essentially of two main parts, the level vial and the level vial holder. The level vial is a hollow, cylindrical piece of glass, both ends of which are closed. It is partially filled with a fluid consisting of alcohol and ether, usually in the proportions of 60:40. The void space in the vial is known as the bubble. It is this bubble from which observations and settings are made. The under side of some level vials is silvered, so that reflection of light from the bottom of the vial will illuminate the bubble. Some vials which are not silvered may require the use of a piece of white paper beneath the vial to render the bubble distinct from all angles of vision. In the center of the top of the vial will be found a series of index marks. The two center marks are spaced the length of the bubble apart. Any additional graduations to the left or right of these two center graduations will indicate fractions of mils, minutes, seconds, or degrees. This measurement is the deviation from the horizontal expressed in some sort of angular measurement. The exact type of measurement that is used will depend on the degree of accuracy expected and the type of instrument on which the level vial will be used.

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74. Level holders.—The level holder is generally of metal, providing a tube of somewhat larger inside diameter than the outside diameter of the level vial. The top of the tube is open so as to expose the graduations and index markings on the vial. In some cases this holder is adjustable in its mount by means of jack screws.

75. Types of level vials in use.—There are many types of level vials in use. The types vary in sensitivity, length, diameter, size, etc. The sensitivity of a level vial is dependent on the interior ground surface and the radius of curvature of the vial. Level vials used by the military service are designated by one or two letters such as vial, level, type E; vial, level, type EE; vial, level, type H; etc.

76. Precautions in use and handling.—All level vials should be handled with extreme care, since any rough usage, jars, shocks, etc., may upset the vial, move the holder, or break the vial. Heat cannot be applied to a level vial at any time, as the expansion of the liquid caused by the application of heat may crack the vial. Level vials should never be subjected to any stress that may conceivably interfere with their accuracy.

77. Adjustments.—*a.* Level vials that are merely out of adjustment may be reset by the instrument section specialist. If broken, replacement will be necessary.

b. There are two general methods by which level vials are secured in their holders—

(1) With packing, such as plaster of paris.

(2) By means of either external or internal adjusting screws.

78. To set level vials held by packing.—To adjust or replace a level vial in its holder the method below should be followed in the case of those held by packing.

a. Remove the unserviceable vial from its holder by removing the packing. Exercise care not to break the vial during this procedure.

b. Clean thoroughly the inside of the holder and the outside of the level vial.

c. If the bottom of the vial is not silvered, place a small piece of clean white paper under the vial and secure in place by use of a minimum amount of shellac.

d. Level the holder and properly set any scales. *If mounted in an instrument at time of this adjustment be sure that the instrument is first leveled.*

e. Be sure to place the vial up with graduations in the center of the holder. Hold the level vial in place and level with small wooden wedges under and over the vial. Under no conditions force the wedges into place, as this may break the vial.

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f. When the vial is level as indicated by the bubble and the index markings, fill the holder with plaster of paris having the consistency of heavy cream. *Make sure that the packing completely fills all of the void space around the vial.*

g. Set aside 2 or 3 hours to dry. When dry remove excess packing from end of holder and replace the holding plugs. Do not force plugs against packing, as this will displace the vial and render useless the work done. Be sure to clean off the excess packing from the top of the vial.

79. To set level vials held by external screws.—*a.* To set and adjust level vials that are held in their holders by means of external screws the following general practice may be followed:

(1) Level the instrument.

(2) Level the holder, if it has an independent leveling device other than the adjusting screws.

(3) Level the vial by means of the jack screws of the holder.

(4) Rotate the instrument 180°; correct for half the error of the vial by releveling the instrument and releveling the vial by adjusting the jack screws of the holder.

(5) Repeat the above procedure until the bubble remains between the index lines. Check for accuracy at each 90° quadrant of the instrument's rotation.

b. The above procedure will apply especially to the AA, BC, M1 telescope; the director M4; and other instruments of a similar type.

80. To adjust level vials held by internal screws.—To adjust level vials held by internal adjusting screws the procedure is simple.

a. Level the instrument.

b. Level the holder until opposite the proper index.

c. Adjust the internal screws until the vial is level.

d. Recheck accuracy of instrument and vial.

SECTION XI

MAGNETIC NEEDLES

	Paragraph
Definition	81
Construction	82
Adjustment	83
Release devices	84

81. Definition.—The magnetic needles used in fire control instruments are the same as the magnetic needles utilized in ordinary compasses. While ordinary compasses are graduated in degrees, military instruments are graduated in mils. The aiming circle (all types

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and models), prismatic compass, and altimeter are fire control instruments that utilize magnetic needles.

82. Construction.—*a.* In the center of the magnetic needle of a good compass there is a jewel held in a housing. This jewel may be of any hard substance such as dense glass, ruby, etc. The jewel rests on a pivot upon which the needle and the jewel rotate. The purpose of this is to allow maximum freedom of rotation so that the compass needle may swing naturally, with a minimum of frictional resistance.

b. Magnetic needles are usually constructed of high carbon steel, which possesses strong magnetic qualities. Only ferrous metals possess magnetic qualities. Some alloys of ferrous metals are stronger magnetically than others.

c. Every magnet has a north and a south pole. The theory is that invisible lines of force emanate from the north pole and flow to the south pole. Consequently, the south pole of a magnetic needle is called the "north seeking" pole, and the north pole of the needle is called the "south seeking" pole.

d. It is definitely known that the north magnetic pole of the earth is not the true North Pole. If tables and maps are available for the locality in which a compass is used, the exact amount of error can be calculated, and the exact north line (geographic north) can be determined. The north point at which the compass needle points is called the north magnetic pole, and its declination from the geographical North Pole is indicated on the margins of standard maps for any given locality.

e. A complete description of the manner in which magnetic needles function will be found in the section on aiming circles in TM 6–220.

83. Adjustment.—*a.* After long usage or due to rough handling and carelessness the jewel of a magnetic needle will wear at the point at which the pivot supports it. The pivot may also wear and become dull. Or, also, in time the magnetic needle will have expended most of its magnetic energy. These are the main defects which will be encountered by the instrument section in the servicing of the magnetic needles and compasses of instruments containing them. They are easily perceptible. Any of them will cause a magnetic needle to become slow, sluggish, and inaccurate.

b. To correct a sluggish needle use the following procedure:

(1) Sharpen the point of the pivot with a fine stone and try the needle.

(2) If this does not correct the defect, remagnetize the needle by placing it on a horseshoe magnet overnight.

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(3) If this does not remedy the defect, the needle will have to be replaced, since the jewel is probably worn.

c. It may occur that when a new needle is placed in an instrument it will be too long and will rub on some projection of the compass housing. They cannot be filed to fit, but they may be stoned. It must be kept in mind that these needles are perfectly balanced, and must be kept this way. In stoning magnetic needles, remove an equal amount of metal from each end, in order to maintain this delicate balance.

d. The stoning of magnetic needles must not be attempted on the M1 aiming circle. These needles have a line engraved on the south seeking pole and its erasure renders the needle unserviceable.

84. Release devices.—In most instruments using compasses and magnetic needles there is a device used to lift the needle off the pivot when the needle is not in actual use. When inspecting the magnetic needles of any instrument be sure that this release device is completely released before deciding that the needle is sluggish.

SECTION XII

WORM AND WORM-WHEEL

Paragraph
Definition 85
Use 86
Adjustment 87

85. Definition.—*a.* The worm and worm-wheel principle is widely used in military fire control instruments as a means of rotating the instrument in azimuth and elevation. It operates on a well-known mechanical principle and has been adopted as the standard for mechanical movements that must be accomplished as indicated above.

b. The worm is the driving member and the worm-wheel the driven member. There can be no reversal of this relationship.

c. The principle of operation is similar to that of the action of a nut and bolt. For ordinary purposes and for illustration imagine that the nut has been cut in half. If the bolt is rotated and kept from moving longitudinally the half nut will travel longitudinally up or down the length of the bolt.

d. On items of fire control and sighting equipment this principle is refined to control the movement of rotation of the worm-wheel. Generally, 64 rotations of the worm will cause one complete turn of the worm-wheel.

86. Use.—*a.* For ordinary military purposes a circle is divided into 6,400 mils, and the worm turns 64 times to complete the circle. It is thus obvious that one turn of the worm is equal to 100 mils of

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rotation. A micrometer dial can then be attached to the worm and this dial can in turn be subdivided into divisions that will aggregate 100 mils. If settings of finer accuracy are desired they can be set upon the micrometer scale. One complete turn of the micrometer scale will move the scale of the worm-wheel but one graduation (or 100 mils).

b. There is an index provided for all micrometers and scales so that the amount of rotation can be easily read.

c. There is practically always a provision made to disengage the worm from the worm-wheel in order to allow a quick rotation of the worm-wheel. It consists of a device known as the throwout lever which is connected to the worm. It functions by means of a cam and plunger.

87. Adjustment.—*a.* The unusual construction of the worm and worm-wheel mechanism provides a means of reducing end play of the worm to a minimum. This is accomplished by having a ball as an integral part of the worm. This ball is set in a ball socket, and a ball cap is screwed down against the ball, thus confining it to a certain given space with no allowable play. If this is done the worm can rotate but cannot move longitudinally. By using a ball instead of a flat collar for this purpose a means is provided to hold the ball end of the worm in place while disengaging the threaded portion of the worm from the worm-wheel. When the throwout lever and cam are released the worm returns to engagement with the worm-wheel under the compressed energy of a spring.

b. In fire control instruments the limit of worm end play must be small enough to preserve accuracy in the 1 to 64 ratio. The allowable error is ½ mil of rotation of the worm. Translated into the rotation of the wormwheel it equals 1/12,800 of a circle. This adjustment is accomplished by screwing the ball cap down onto the worm ball until the worm cannot be turned, and then backing off on the ball cap a little until the worm turns smoothly. This method should be repeated until the worm works freely, yet not loosely. If, after the worm is free, there is an excessive amount of backlash, the fault lies with the mesh of the teeth of the worm and the worm-wheel. This will entail the refitting of a new worm or worm-wheel or the machining of the housing to accommodate a closer mesh of the parts.

c. Backlash, if present, can be detected by using the following test: Mount the instrument on its tripod, or in a fixture, and set all micrometers and scales to read zero. Rotate the instrument by means of the azimuth knob to the right until the cross lines of the reticle are trained on a clear and well-defined point. It does not necessarily have to be a testing target. Continue on to the right for a few mils and return to

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the left until on the original reference point. Read the micrometer. If the reading does not agree with the zero reading set before the operation, backlash is present in the proportion indicated by the difference in the two readings.

d. If backlash exists in excess of ½ mil an adjustment is required. This same test can be used on angle-of-site and elevation mechanism.

e. In instruments which do not operate on the principle of the worm ball throwout mechanism, the entire worm must be moved away from the worm-wheel when it is necessary to disengage the teeth. This condition is found on the French aiming circle M1918 and the range finder mount. The worm is moved out of engagement with the worm-wheel by means of eccentric bushings which rotate in the azimuth housing. End play in this case is eliminated by using washers between the micrometer, or the knob, and the bushing.

f. The meshing of the worm and the worm-wheel is controlled by means of a large-headed screw in the housing. The head of the screw acts as a stop for the throwout lever. It is common practice to file away enough of the head of this screw to allow for the wear of the teeth of the worm.

SECTION XIII

STORAGE OF FIRE CONTROL INSTRUMENTS

	Paragraph
General	88
General instructions	89
Company or battery storage	90
Safeguarding matériel in storage	91

88. General.—*a.* The instructions contained in this and the next paragraph apply to fire control and sighting matériel not in general use, and especially to matériel in post storage. The object is to see that the matériel is maintained in the best possible condition with the least expense. The location and the period of time that the matériel is to be stored will govern the amount of disassembly and the treatment taken to prevent deterioration.

b. Matériel storage.—Matériel is usually stored in either post storage or depot storage.

(1) There are two kinds of post storage; one at regular Army posts, camps, and stations; and the other at headquarters of units of the civilian components.

(2) Depot storage is storage at ordnance establishments and at sections of general or branch depots. The matériel in depot storage is maintained in accordance with instructions outlined in OFSB 4–4, which may be supplemented by the instructions contained herein.

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c. Before any item of ordnance matériel is stored reference should be made to Technical Manuals, War Department Documents, Ordnance Pamphlets, Ordnance Field Service Bulletins, and other publications relative to the care and maintenance of ordnance matériel. It is important that reference be made to pertinent Technical Manuals and to TM 9-850. The last-named publication contains valuable information relative to the cleaning and preserving materials for use on ordnance matériel.

89. General instructions.—*a.* All machined surfaces should be thoroughly cleaned and coated with rust-preventive compound. A permanent coating cannot be applied to machined surfaces in cold weather unless it is possible to heat the matériel being coated. If it is not possible to heat the matériel, a temporary coating should be applied, and the permanent coating deferred until weather conditions become more favorable. Rust-preventive compound is not a lubricant and must be replaced by the designated lubricant prior to returning any article to service.

b. All surfaces requiring painting for proper preservation shall first be thoroughly cleaned to remove rust and dirt, and then painted. See section VIII for painting instructions.

c. All means of lubrication, including grease cups, grease and oil fittings, oil cups, oilholes, and oil passages, shall be cleaned and repaired, and a generous quantity of the prescribed lubricant forced into the bearings or other surfaces.

d. All matériel will be placed in serviceable condition if practical before being stored, and should be placed under cover and in the most favorable storage available.

e. Fire control and sighting equipment will be clean, placed in their cases, and packed in boxes for storage. Most of these instruments have carrying cases provided; therefore, care will be exercised to see that instruments are placed in their carrying cases. Often, if the instruments are not properly placed in their carrying cases, eyeguards will be crushed out of shape, or other parts may be placed under stress when the cases or boxes are closed.

f. All exposed, unpainted surfaces on delicate instruments will be protected with a light coat of oil. Excessive use of oil for this purpose is dangerous, since it may run and cause damage to the optical components of the instrument.

g. Night lighting devices, wiring switches, and lamps that are readily removed from the instrument will be stored in the same box as the instrument. Batteries will not be stored in the same box as an instrument.

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h. Telescopes for which separate cases are provided should be packed securely in their cases with old paper. This paper must be dry. The use of old paper in this manner will tend to absorb moisture as well as serve as a shock-absorbing packing material.

i. Rubber eyeguards should be washed with mild soap and warm water, dried, and then dusted with French chalk. Care must be taken to store eyeguards so as to prevent their being crushed out of shape.

j. Large pedestals and mounts may be left on their bases, provided the unpainted surfaces have been coated with rust-preventive compound and covered with well-fitting wooden covers or other suitable means of protection.

k. Instruments will be stored in a clean, dry place maintained at an even temperature. This temperature should never be less than 50° F. Dunnage will be placed on the floor and between each box so as to provide for free circulation of air.

90. Company or battery storage.—*a. General.*—Paragraphs 88 and 89 had reference to matériel to be placed in post or depot storage. It was contemplated that these instruments were not in use, nor would be for a period of time. A slightly different situation confronts the commander who must have his instruments available at all times for training purposes. Information condensed from OFSB 4–8 pertinent to the problem of company or battery storage appears in *b* to *j*, inclusive, below.

b. Hot storage.—Fire control instruments will be stored in a clean, dry place maintained at an even temperature. Hot storage is not difficult to provide and has proved satisfactory.

c. Locations of hot-dry lockers.—(1) The best and most economical place to construct hot-dry lockers is in an attic space; such attic spaces are very good without the addition of artificial heat.

(2) In the absence of proper attic space the location selected should be one where maximum advantage may be taken of the heat of the sun.

d. Construction of hot-dry lockers.—(1) The best dry lockers are built of good, tongue and groove, well-seasoned lumber to prevent shrinking. If the best lumber is not available, the locker should be sealed with building paper.

(2) The locker should be double-walled construction with an air space between it and the roof. This provides an insulating air cushion preventing rapid radiation.

(3) Ceiling height should not be over 10 feet, and preferably 8 feet.

e. Ventilation of hot-dry lockers.—(1) Ventilation is one of the most important factors in good hot-dry storage. Warm saturated air passes

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off through the ventilator, while the incoming air, heated as it enters, takes up moisture as it passes through the locker and out through the ventilator. Without ventilation the air may reach the saturation point, then there will be no further evaporation, and should the temperature suddenly fall, there would be condensation.

(2) A ventilator should be provided in the ceiling of each dry locker and at each heat unit installed in the locker.

(3) During the dry season the locker should be left open for fresh air circulation from 10 AM to about 4 PM each day. This is the period of low relative humidity.

(4) During the wet season the locker should be left open only when rain is not actually falling. From 12 noon to 2 PM is the best time for this purpose, as this is the period of lowest relative humidity.

(5) Ventilators should always be cut in the interior walls of the dry locker, and never in the outer walls.

f. Heating of hot-dry lockers.—(1) Hot-dry lockers located in attic space require very little if any artificial heat.

(2) Hot-dry lockers so located that the heat of the sun is effective most of the daylight hours require only a small amount of artificial heat (about 0.2 watt per cubic foot of air space).

(3) Hot-dry lockers so located that the heat of the sun is effective for only a small part of the day, or not at all, should have artificial heat applied at the rate of 0.35 to 0.4 watt per cubic foot of air space.

(4) Heat units should be installed on the floor. For small lockers Edison base resistance coils should be used, but for the average domestic dry locker, the use of electric lamps will usually be found effective. This, however, will be less economical, due to the frequent burning out of lamps from excessive use.

(5) For large installations in depots the use of a time switch to control the current during the dry season will prove to be economical.

(6) For the storage of delicate and expensive items the installation of electric fans, in addition to heaters, to keep the air constantly in motion will make the locker more efficient and is justified in some extreme cases for depot use.

(7) As a rough check on the effectiveness of a hot-dry locker, a thermometer may be installed and read at intervals. As an additional check occasional readings may be taken with a sling psychrometer to determine definitely the relative humidity.

g. Storage of celluloid articles.—(1) Articles manufactured from celluloid should be protected from light and kept free from contact with steam pipes or other sources of heat while in storage.

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(2) Large numbers of celluloid articles should not be packed solidly in boxes or other containers, but should be wrapped separately or some means taken to separate each article from the other.

h. Inspection.—Each month several instruments selected at random will be removed from storage and inspected to ascertain how the matériel is holding up under storage conditions.

i. Director M4.—For storage of the antiaircraft director M4 see TM 9–2655 and TM 9–360.

j. Height finder.—For storage of the height finder see TM 9–360.

91. Safeguarding matériel in storage.—*a.* The comments included in previous paragraphs have been aimed at keeping the matériel concerned in serviceable condition during the period of storage. Such precautions as may be considered necessary will be taken to insure that all matériel in storage is safeguarded to the greatest possible degree.

b. All matériel, while in storage, must in addition be adequately protected from fire, theft, and other harm. This is the responsibility of the personnel who are in charge of the warehouse where the matériel is stored.

Section XIV

SHIPMENT, PACKING, AND HANDLING OF FIRE CONTROL EQUIPMENT

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General	92
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92. General.—The instrument section in the field will often be called on to prepare items of fire control and sighting equipment for shipment and storage. This may range from the packing of a single instrument to the packing of several hundred. For the preparation of instruments for storage refer to section XIII. Instructions pertinent to the shipment of fire control instruments will be found in the following paragraphs.

93. Handling large numbers of instruments.—*a.* If large numbers of instruments are to be handled they should first be segregated into groups according to their group classifications in the ordnance catalog. In the rear or "notes" section of the standard nomenclature list for each instrument will be found a short section

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containing instructions and authorized specifications relative to the shipment and packing of the particular instrument concerned. The following example may be illustrative of the information contained:

b. Standard Nomenclature List F-3 covers the sight, telescopic, M1918. In the rear of this SNL is a section headed "Weight and Volume and Method of Packing" containing the following information:

Kind of container	Wooden box.
Dimensions (approximate)	1.5 ft. long, 1 ft. wide, 0.5 ft. high.
Quantity packed in container	2
Cubic feet (approximate)	0.75
Square feet (approximate)	1.5
Weight of packed container (lbs.)	17
Weight per square foot of floor space	11.33

c. These instructions, found in every SNL, of which the above quoted example is typical, afford adequate information relative to the packing and shipping of large numbers of instruments.

94. Packing.—In placing fire control instruments into their cases care should be exercised never to exert undue force. The case and the packing blocks contained therein are carefully designed to fit the fire control instrument to which they apply, and if the instrument is properly handled it will easily fit into the case provided. No other case than the one provided will be used. Matériel received for repair at the arsenals from the field often have deformed eyepieces and sunshades which are beyond repair. Some of these instruments are new, showing no indications of having been used. It is, therefore, assumed that they have been taken from the cases for inspection or other purposes and are damaged when replaced in the cases. Instruments should be returned to the cases, objective end down, which will leave sufficient space for the placing of the eyepiece rubber, the sunshade being placed inside of the eyepiece rubber.

95. Packing for shipment.—*a.* Frequently unserviceable fire control instruments are received for repair at the arsenals improperly packed, with the result that the instruments are subjected to additional damage during shipment, thereby increasing the cost of overhaul. It is essential that as much care be taken in packing unserviceable equipment for shipment to an arsenal as is taken in packing serviceable equipment. The instruments must be shipped in their covers, carrying cases, and packing chests, *which in turn must be carefully packed.*

b. When covers, carrying cases, or packing chests are not provided or are not available, extra precaution must be taken in packing to avoid damage in shipment.

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96. Shipping complete components.—*a.* When returning unserviceable equipment, the complete instrument as listed in SNL's F–1, F–2, or F–3 will be forwarded, except that certain instruments reviewed under SNL F–2, due to their size, may be forwarded incomplete, but care will be exercised to forward the complete components that are affected by the repair.

b. These instructions do not prohibit the turning in for repair of tripods with carrying cases whenever the tripod is the only part of the instrument that is unserviceable.

97. Unserviceable fire control equipment.—Occasionally fire control instruments will be received in the shop for repair which are beyond all available facilities and skill, and are irreparable by the instrument section in the field. If this unserviceability is obviously the result of fair wear and tear the instrument or instruments may be shipped to an arsenal or other higher unit of maintenance for repair or replacement in accordance with such instructions as may be issued by the division or corps area ordnance officer. The deciding authority in this instance will vary with the location and function of the particular instrument section concerned.

98. Excess damage to unserviceable instruments.—Frequently the condition of field glasses, watches, time interval recorders, and like instruments turned in as unserviceable does not appear to be the result of ordinary wear and tear in the service, inasmuch as they could not possibly have been used in the condition turned in, and the degree of unserviceability is greatly in excess of that which ordinarily justifies the turning in for repair. The condition is often such as to indicate that these articles have either been tampered with or become further damaged through accident or design, with results that in some instances they are beyond repair, or the cost of repair is excessive. When field glasses, watches, time interval recorders, and like instruments fail to function correctly they should be ordered in for repair at once, and no attempt at repair should be made at other than authorized repair establishments.

99. Action at repair establishments.—*a.* When unserviceable fire control equipment is received in unserviceable condition beyond that due to fair wear and tear, and not covered by report of survey or inventory and inspection report, or when the report of survey or inventory and inspection report does not cover the condition of unserviceability in which the instruments are found upon receipt, an over, short, and damaged report will be instituted under the provisions of AR 35–6640, unless the carrier accepts responsibility for the damage.

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b. When conditions such as those listed in paragraph 98 and *a* above are found to exist it is not the job of the specialist to determine the causes of unserviceability. It is the responsibility of the section chief to see that the above instructions are carried out. In his absence the senior member of the section will take the appropriate action.

SECTION XV

ORDNANCE MAINTENANCE

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100. General.—The material in this section has been compiled from various War Department and Ordnance Department publications so as to present a general and comprehensive picture of ordnance maintenance activities. The source of each numbered paragraph is given in parentheses after each paragraph. Reference to the publication concerned is advised for more detailed information.

101. Maintenance.—*a. Ordnance Field Service.*—The Ordnance Field Service is that branch of the Ordnance Department charged with the supply, the maintenance in service and in storage, and the alteration and inspection of such matériel as is or may be allotted to the Ordnance Department for storage or issue.

b. Reponsibility of commanders.—The commanders of corps areas and exempted stations are responsible for the supply of troops within their jurisdiction, and for the alteration and inspection and proper maintenance of ordnance matériel in accordance with the regulations and detailed instructions issued by the Chief of Ordnance.

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c. Matériel to be kept in serviceable condition.—(1) All ordnance matériel will be kept in such condition that it can be placed in use promptly.

(2) Prompt steps will be taken to repair all damaged matériel to the extent that available facilities permit.

(3) No officer will turn in any unserviceable ordnance stores except as prescribed in regulations.

(4) Matériel which cannot be repaired locally will be reported to the ordnance officer of the next higher unit in order that he may arrange for suitable facilities and mechanics, or order the matériel shipped to an arsenal for repair.

(5) Where the extent of repair or disassembly can be undertaken within an organization as prescribed in Technical Manuals or other instructions, if such work is beyond the capabilities and facilities of available personnel, such repairs and disassemblies will not be attempted but will be handled as in (4) above or *h* or *i* below.

(6) Changes in firearms and other articles, such as filing, polishing, rebluing, and attempting to beautify, which are not specifically authorized, are forbidden.

d. In corps areas.—Except at exempted stations, the maintenance of ordnance matériel under control of the War Department is under the jurisdiction of the corps area in which the matériel is located.

e. At exempted stations.—(1) At exempted stations having an officer of the Ordnance Department detailed as ordnance officer, the maintenance of ordnance matériel will be directly under the supervision of the Chief of Ordnance.

(2) At exempted stations where no officer of the Ordnance Department is detailed as ordnance officer, the maintenance of ordnance matériel will be under the jurisdiction of the corps area.

f. Matériel issued to other arms or services for special purposes.—Ordnance matériel used by other arms or services for purposes not contemplated by Tables of Organization or Tables of Basic Allowances will be maintained by the using service, for example, ordnance tractors used by the Quartermaster Corps for utilities work will be maintained by the Quartermaster Corps.

g. Distribution of funds.—The Chief of Ordnance will make such distribution of funds available for maintenance purposes to corps areas and exempted stations as the best interests of the service demand.

h. Facilities.—(1) The facilities for the maintenance of ordnance matériel at exempted stations or in the hands of troops under the command of corps area commanders include—

(*a*) Ordnance officers.

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(*b*) Ordnance companies (maintenance) with their equipment, machine tools, and qualified civilian or enlisted mechanics.

(2) When additional facilities are necessary corps area ordnance officers will apply therefor, by authority of their respective corps area commanders, to the Chief of Ordnance, who will provide such additional facilities as may be necessary and available.

i. Repairs at arsenals, etc.—(1) When repairs to ordnance supplies cannot be made within a command with the means provided for that purpose, they will be made with such other agencies as the Ordnance Department will provide.

(2) In conformity with instructions issued by the Chief of Ordnance, corps area ordnance officers may, by authority of their respective corps area commanders, order articles of ordnance matériel shipped to an arsenal or depot for repair or alteration.

102. Using organizations.—The first phase of maintenance (preventive) consists of the proper operation and servicing, including lubrication, and the making of timely minor repairs, in accordance with pertinent Ordnance Department publications. This is the responsibility of the using personnel, with technical advice and assistance from the ordnance officers concerned. The repairs authorized for this phase are restricted to those specified for each type of matériel (OFSB 4–1, par. 3).

103. Procedure.—Instructions concerning the procedure to be followed in this phase of the maintenance appear in the following publications: Technical Manuals; Standard Nomenclature Lists; Ordnance Field Service Bulletins; and notes on special items issued in special pamphlet form, correspondence, diagrams, charts, and drawings. If copies of these publications, etc., are not available to the using arms or services, the respective ordnance officers furnishing technical advice and assistance should make every effort to furnish pertinent abstracts to the using service (OFSB 4–1, par. 7*b*).

104. Supplies and parts.—Tools, facilities, sets of parts, and materials will be made available in sufficient quantity and quality to enable the using arms to perform the proper cleaning, preserving, and repairing, renewal of lost, worn, or damaged parts, and such other preventive maintenance as they are authorized to perform (OFSB 4–1, par. 7*b*).

105. Post detachments.—When conditions warrant, due to a large quantity of matériel requiring maintenance, a post detachment of experienced ordnance personnel may be assigned. The Ordnance Department will be qualified to make more extensive repairs through this detachment, and will be capable of advising in ordnance practice.

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More extensive tool equipment and augmented stocks of spare parts and materials will therefore be made available to such detachments (OFSB 4–1, par. 8*b*).

106. Ordnance maintenance companies.—Ordnance maintenance companies are organized primarily to provide skilled personnel, shop and other tools, and supplies for the maintenance of ordnance matériel. These companies should be used to the fullest degree for proper maintenance. These maintenance companies are equipped to perform various kinds of repair work. Additional facilities will be made available when possible upon the recommendations as directed in paragraph 3*f*(2), AR 45–30. Ordnance maintenance companies are provided with mobile shop facilities in accordance with Tables of Basic Allowances—Ordnance Department. Certain of these companies are located where permanent shops and facilities are available. These facilities are manned by the personnel of the companies (OFSB 4–1, par. 9).

107. Responsibility of maintenance company.—These maintenance companies are charged with the responsibility of carrying or having available sets of basic spare parts sufficient in quantity to maintain the equipment they are called upon to service (OFSB 4–1, par. 9*c*).

108. Facilities for maintenance.—These facilities are further described as follows:

a. Personnel.—Officers of the Ordnance Department, officers of other arms or services designated as post ordnance officers, warrant officers, enlisted personnel of the Ordnance Department assigned as individuals or organized into detachments and ordnance companies, and civilian personnel specially trained in ordnance practice.

b. Repair and replacement parts and cleaning and preserving materials issued in accordance with the provisions of AR 35–6540.

c. Repair shops.—Buildings and equipment provided specifically for the purpose of overhauling and repairing ordnance matériel, and equipment mounted on trucks. Shops include harbor defense and post repair shops (permanent) as well as mobile shops manned by ordnance personnel.

d. Special tools and machines furnished by the Ordnance Department.—When additional equipment is required, it will be furnished, if practical, upon receipt of recommendations in accordance with AR 45–30 (OFSB 4–1, par. 4*a*).

109. Overhaul.—It is desirable to overhaul ordnance matériel in active service at least once a year. This may be accomplished by arranging with corps area ordnance officers for the assignment of

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civilian mechanics and by the assignment of ordnance enlisted detachments. Or, if practical, the equipment may be taken to the shops of the ordnance maintenance companies.

110. How overhaul is accomplished.—A schedule should be arranged by the ordnance officers, in consultation with the organization commanders, so as to take each unit in turn. Due consideration must be given the training schedules of the organization. When it is impossible to arrange a schedule of overhaul so that the training periods of the organizations will not be seriously interrupted, spare equipment will be issued when available (OFSB 4–1, par. 10*b*).

111. Equipment removed from organizations.—All equipment physically removed from the location of an organization should be covered with the issuance of an informal receipt furnished the organization commander, noting thereon serial numbers of the respective pieces, general condition, shortages of equipment, if any, and any serious damage to nonexpendable parts (OFSB 4–1, par. 10*c*).

112. Limits of overhaul.—Matériel undergoing overhaul should be dismounted to such a point that it can be rebuilt and placed in first-class condition. Parts worn to such an extent as to interfere with the accuracy and functioning of the matériel, or which, it is estimated, will not last until the next overhaul, should be replaced. Entry should be made in the gun book or motor log book, where applicable, of a brief history of the overhaul, and initialed by the supervising officer (OFSB 4–1, par. 10*d*).

113. Time and cost accounting, field shops.—*a.* All ordnance repair shops operating in the field will maintain a system of time and cost records. All persons and detachments doing repair work will also maintain abbreviated time and cost records.

b. FM 9–10 contains a description of shop operation which includes a system of time and cost records that is simple and effective. The system described has been used successfully for a number of years by ordnance maintenance companies. This publication also includes information regarding the functions and operation of the instrument section of the company.

c. Time and cost records maintained under the above system will make available data which may from time to time be required by the Chief of Ordnance and can be readily abstracted.

114. Drawings.—*a.* Complete files of ordnance drawings with revisions will be maintained at the establishments designated to serve the respective corps areas, departments, and exempted stations.

b. The ordnance officers at the several posts, camps, and stations requiring prints or drawings are directed to submit requisitions,

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through their respective corps areas or department ordnance officers, to the arsenal designated to serve them (OFSB 4–1, par. 12).

115. Use of arsenal facilities.—When repairs to ordnance matériel cannot be made with the facilities immediately under the control of the ordnance officers of the corps areas, departments, or exempted stations, such matériel will be turned in to the respective establishments designated in OFSB 4–1, paragraph 18*a*.

116. Alteration of ordnance matériel.—*a*. The Chief of Ordnance, under the Secretary of War, is charged with the responsibility for issuing instructions for all alterations and modifications of ordnance matériel (AR 45–30, par. 4*a*).

b. The general method of issuing such instructions is through the media of field service modification work orders prepared in the office of the Chief of Ordnance.

c. Such instructions may, however, be issued in the form of correspondence to meet emergency or unusual conditions.

d. Progress of all work done in applying alterations and modifications will be reported to the Chief of Ordnance. Forms and instructions for preparing progress reports on field service modification work orders are outlined in paragraph 8, OFSB 4–5 (OFSB 4–1, par. 15).

117. Reasons for modification.—Modification is one of the means by which the Ordnance Department maintains ordnance equipment in a ready and serviceable condition to meet any emergency. It is defined in a general way as follows: modification is a specific major or minor change in the design or assembly of an adopted type of product. Modifications are required or adopted for existing types of equipment to improve functioning, to obtain economical maintenance, to provide greater safety, to remove superseded elements or components, or remove obsolete parts. Field service modification work orders are published to provide authentic and uniform instructions for the physical application of authorized modifications to accomplish any of the purposes listed above.

118. Nature of field service modification work orders.—*a*. The instructions for modifications incorporated in field service modification work orders are based on the revision of drawings as prepared by the manufacturing service together with the pertinent data published or available in the Ordnance Department records or on reports from the field on physical tests. The request for modifications may be initiated by any branch of the Ordnance Department or from outside services. Modification with reference to field service modification work orders is interpreted therefor as follows:

(1) Modification which involves a mechanical operation only (example: F–84–W1).

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(2) Modification which involves the modification of a part plus disassembly and assembly incident thereto, or the modification of a part and the installation of an additional part plus the assembly and disassembly incident thereto (example: F–67–W2).

(3) Modification which involves the removal of a part with no replacement other than plugging of holes, etc. (example: F–56–W1).

(4) Modification which involves the removal of an old part and the installation of a newly (superseding) designed part plus the assembly and disassembly incident thereto (example: F–25–W1).

b. Whenever it becomes necessary to issue additional instructions or information pertaining to the alteration or modification of matériel already covered by a work order, a change will be issued covering such alteration or modification and containing such instructions as may be necessary. The change will be given the same designation as the original work order except that it will also have the letter (C) and the number of the change suffixed, denoting whether it is the first, second, third, etc., change issued to that particular work order (OFSB 4–5, par. 7).

119. Unauthorized modifications and alterations.—*a.* No alterations or modifications will be made prior to the approval of the Chief of Ordnance.

b. The following unauthorized alterations and modifications are the cause of more than one serious and fatal accident:

(1) Changes in the working parts of ordnance matériel.

(2) Use of unauthorized cleaning agents and bleaching agents which remove filler or dressing from leather, causing cracking, rotting, etc.

(3) Tampering with optical elements of sighting and fire control equipment, or the removal of lacquer, enamel, and other such finishes from these items.

Not only do these things cause serious accidents, but they tend to damage or ruin ordnance matériel as well.

SECTION XVI

TRAINING SCHEDULE

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General	120
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120. General.—In this section will be found information which should be useful in the construction of a comprehensive training schedule for personnel of the instrument section. Unit A should precede Unit B in the sequence of instructions. Time allotted any

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particular portion of either unit can be arranged to coincide with local conditions.

121. Unit A.—This unit consists entirely of theoretical instruction, given by lecture and demonstration, and affords a basic groundwork of necessary knowledge, which will greatly simplify the practical portion of the training schedule, Unit B.

a. Elementary optics.—References: TM 9–2601 and any optical texts available.

(1) Illumination.
(2) Reflection.
(3) Refraction.
(4) Lenses.
(5) Prisms.
(6) The human eye.
(7) Magnification.
(8) Telescopic systems.
(9) Erecting systems.
(10) Spectra and color.
(11) Defects in lenses.
(12) Reticles.
(13) Mil system of measurement.

b. Elementary machine shop practice.—Reference: TM 9–2603.

(1) Hand tools and their use.
(2) Machine tools.
(3) Screws and screw threads.
(4) General shop practice.
(5) Safety precautions.
(6) Ferrous and nonferrous metals.
(7) Soldering and brazing.

c. Cleaning, painting, and sealing of instruments.—Reference: TM 9–2602.

(1) Cleaning lenses and prisms.
(2) Cleaning metal components.
(3) Painting metal components.
(4) Sealing compounds and their uses.
(5) Use of reference material.

122. Unit B.—Instruction is given by lecture and demonstration, during which time the instructor covers the operation, care and handling, disassembly and assembly, and inspection and adjustment of each instrument on the schedule. Special attention is given to the more common optical and mechanical defects. Each student is given an opportunity to adjust, use, inspect, and disassemble and assemble

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different kinds of instruments. He is taught the difference between repairs which can be made in the field and those which require shop or arsenal facilities.

NOTE.—If the time available must be taken into consideration, the instruction should be confined to those instruments which the section services the most.

a. Operation and construction.—(1) Use and operation.
(2) Mechanics of the instrument.
(3) Optical elements.
(4) Accessories.
b. Disassembly and assembly.—(1) Care.
(2) Methods.
(3) Limits.
c. Tests and adjustment.—(1) Procedure.
(2) Accessories for adjustment.
(*a*) Targets.
(*b*) Tools, jigs, and fixtures.
d. Maintenance.—(1) Facilities required.
(2) Tools, jigs, and fixtures.
(3) In the field.
(4) In the shop.
(5) Storage.
(6) Transportation and shipment.
e. Inspection.—(1) Forms.
(2) Procedure.
(3) Defects.
(*a*) Mechanical.
(*b*) Optical.

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APPENDIX

LIST OF REFERENCES

1. Army Regulations.—The following Army Regulations contain information which will be found useful in the operation of the instrument section. The regulations will undoubtedly be accessible in the headquarters of the organization of which the section is a unit.

AR 20–35 Inspector General's Department: Inspection of Property for Condemnation.
AR 30–2145 Quartermaster Corps: Unserviceable Property, including Waste Material.
AR 35–6520 Finance Department: Property Accountability and Responsibility.
AR 35–6560 Finance Department: Receipt, Shipment, and Issue of Property.
AR 35–6620 Finance Department: Expendable Property.
AR 35–6640 Finance Department: Lost, Destroyed, Damaged, or Unserviceable Property.
AR 35–6680 Finance Department: Transfers of Property Accountability.
AR 35–6700 Finance Department: Property Records.
AR 45–5 Ordnance Department: General Provisions.
AR 45–80 Ordnance Department: Ordnance Property.
AR 310–60 Military Publications: Tables of Organization, Tables of Basic Allowances, and Tables of Allowances.
AR 700–10 Supplies: Storage and Issue.
AR 850–15 Miscellaneous: Military Motor Vehicles.

2. Field Manuals.—*a.* The following Field Manuals contain information that will be found useful or necessary in the operation of the instrument section.

FM 5–20 Camouflage.
FM 5–35 Reference Data.
FM 9–5 Ordnance Field Manual.
FM 9–10 The Ordnance Company, Medium Maintenance.
FM 21–6 BFM, List of Publications for Training, including Training Films and Film Strips.
FM 25–10 BFM, Motor Transport.

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b. Certain of the above listed publications are still in the process of preparation.

3. Technical Manuals.—The following Technical Manuals contain information that will be found useful or necessary in the operation of the instrument section.

TM 6-220 Field Artillery Fire Control Instruments.
TM 9-850 Cleaning and Preserving Materials.
TM 9-1100 Matériel Inspection and Repair.

4. Ordnance Field Service Bulletins.—Ordnance Field Service Bulletins are of great value in interpreting Army Regulations and supplementing available reference material with additional and more explicit instructions. A brief glance at the contents will soon familiarize personnel with the scope and purpose. For a full list of the subjects covered therein refer to the index to the series OFSB 1-1. The OFSB's listed below have been selected as containing information of particular interest to the instrument section:

OFSB 1-1 Subject Index to Entire OFSB Series.
OFSB 1-3 General Instructions: Ordnance Field Service Organization and Functions.
OFSB 1-5 General Instructions: Supervised Articles of Ordnance Matériel.
OFSB 4-1 Maintenance of Matériel in Hands of Troops.
OFSB 4-2 Spare Parts and Tools.
OFSB 4-3 Preservation of Matériel Not in Regular Use.
OFSB 4-4 Overhaul and Maintenance in Depot Storage.
OFSB 4-5 Alterations.
OFSB 4-8 Special Instructions: Group F Matériel.
OFSB 6-F-1 Lubrication Instructions for Fire Control Instruments.

5. U. S. Army Specifications.—U. S. Army Specifications are published for all items of fire control equipment. They contain information that is valuable for reference purposes. The two listed below will be found of particular value:

100-2D Specifications for marking shipments.
51-70-1 General specifications for the painting and finishing of fire control instruments.

6. Standard Nomenclature Lists.—*a.* Standard Nomenclature Lists or "SNL's" are essential publications. A complete set of SNL's is known as the ordnance catalog. The index to this system is the OPSI or Ordnance Publications Supply Index. The instrument section is primarily interested in the "F" group of SNL's, since these review all the items of fire control and sighting equipment which are

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serviced by the section. The SNL's listed below are the index publications for the "F" group. In them can be found the SNL number of any desired instrument.

SNL F-1 Reviews major items of small arms, automatic gun, trench mortar, and field artillery sighting equipment, and fire control instruments.

SNL F-2 Reviews major items of harbor defense, railway and antiaircraft artillery sighting equipment, and fire control instruments.

SNL F-3 Reviews all items not authorized for general issue.

SNL F-5 Merely an arbitrary symbol found in the note symbol columns of all SNL's of the "F" group, which indicates that the parts concerned and identified by this symbol are common to two or more instruments.

b. The publications above will give the correct nomenclature, price, SNL number, and complete components of all sighting and fire control instruments. For more detailed information on any particular instrument refer to the proper SNL that covers it in detail.

7. Field Service Modification Work Orders.—A complete file of all FSMWO's and the index should be available to all instrument sections in the field.

8. Drawings.—The instrument section in the field should have as complete a set of drawings of the instruments most commonly serviced as it is possible to procure. These are invaluable for the disassembly, adjustment, and assembly of various instruments.

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G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

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